DOCUMENT RESUME

ED 295 621 IR 013 331

AUTHOR	Simonson, Michael R., Ed.; Frederick, Jacqueline K., Ed.
TITLE	Proceedings of Selected Research Paper Presentations at the 1988 Convention of the Association for Educational Communications and Technology and Sponsored by the Research and Theory Division (10th, New Orleans, Louisiana, January 14-19, 1988).
SPONS AGENCY	Association for Educational Communications and Technology, Washington, D.C.
PUB DATE	Jan 88
NOTE	866p.; For individual papers, see IR 013 332-385. For the proceedings of the 1986 and 1987 conferences, see ED 267 753 and ED 285 518.
PUB TYPE	Collected Works - Conference Proceedings (021) -- Reports - Research/Technical (143)
EDRS PRICE	MF06/PC35 Plus Postage.
DESCRIPTORS	*Cognitive Psychology; *Computer Assisted Instruction; *Educational Technology; Epistemology; *Ethics; Feedback; *Instructional Design; *Learning Theories; Media Research; Psychological Studies
IDENTIFIERS	AECT Research and Theory Division Meeting

ABSTRACT

The 54 papers in this volume represent some of the most current thinking in educational communications and technology. Individual papers address the following topics: feedback in computer-assisted instruction (CAI); cognitive style and cognitive strategies in CAI; persuasive film-making; learning strategies; computer technology and children's word recognition automaticity; the development of an intelligent technical information system; CAI strategies and achievement; cooperative learning at the computer; instructional development and interactive video; locus of control and CAI; the effects of screen and text density on CAI; design of computer-based simulations; perceived credibility of female peer talent in computer instruction; academic preparation for instructional technology and competency and job success; computer animation and instructional design; instructional intervention for hearing-impaired adults; theoretical foundations of educational technology; design of CAI software for teachers without programming experience; individualizing CAI; an application of the Fishbein attitude-behavior consistency model to learning computer operation; heuristic methods applied to the design of intelligent CAI; professional ethics; cognitive psychology, cognitive processing, and instructional design; cognitive style and subliminal instruction; programming of a concept learning lesson and branching; and instructional development and teacher education. Also included are a symposium on technological equity and a proposal for a "third wave" educational system. Cumulative author and descriptor indexes for the 1985, 1986, 1987, and 1988 conference proceedings are provided. (EW)

ED 295 621

10th ANNUAL

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of
SELECTED
RESEARCH PAPER PRESENTATIONS
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PROCEEDINGS OF SELECTED RESEARCH PAPER PRESENTATIONS

at the 1988 Convention of the
Association for Educational Communications and Technology
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in
New Orleans, LA

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PREFACE

For the tenth year, the Research and Theory Division of the Association for Educational Communications and Technology (AECT) is publishing these Proceedings. Papers published in this volume were presented at the national AECT Convention in New Orleans, LA. A limited quantity of this volume were printed and sold. It is also available on microfiche through the Educational Resources Information Clearinghouse (ERIC) system.

REFEREEING PROCESS: All research papers selected for presentation at the AECT Convention and included in this Proceedings were subjected to a rigorous blind reviewing process. Proposals were submitted to Dr. John Wedman of the University of Missouri, who coordinated the review process. All references to author were removed from proposals before they were submitted to referees for review. Approximately fiftly percent of the manuscripts submitted for consideration were selected for presentation at the Convention and for Publication in these Proceedings. The papers contained in this document represent some of the most current thinking in educational communications and technology.

This volume contains two cumulative indexes covering the most recent four volumes, l985 - l988. The first is an author index. The second is a descriptor index. The two indexes will be updated in future editions of this Proceedings. The index for volumes l-6 (l979-84) are included in the l986 Proceedings.

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ERIC DOCUMENT NUMBERS
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1980	Denver	194061
1981	Philadelphia	207487
1982	Dallas	223191 to 223236
1983	New Orleans	231337
1984	Dallas	243411
1985	Anaheim	256301
1986	Las Vegas	267753
1987	Atlanta	285518

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Title:

The Effect of Computer Based Feedback on Using Cognitive Strategies of Problem Solving

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The Effect of Computer Based Feedback on Using Cognitive Strategies of Problem Solving

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Running Head: Feedback Effect on Cognitive Strategies
Submission Date: December 14, 1987

ABSTRACT

The purpose of the study was to investigate the effects of solution oriented and strategy oriented feedback. The feedback confirmed problem solving strategies that were either similar to the learner's cognitive strategies i.e., spatial strategies, or different from the learner's cognitive strategies i.e., perceptual strategies. The dependent variables were: 1) the number of problems the learner solved correctly within a limited time, and 2) the number of learners who shifted to better choices on a questionnaire designed to measure their cognitive strategies. The subjects were 65 undergraduate students. Four computer programs were designed to instruct the subjects on spatial or perceptual strategies to solve three-term series problems, using strategy or solution feedback. The method of instruction was guided discovery. Significant interaction was found. The results partly supported a theoretical framework. Several questions were raised for future research.

The Effect of Computer Based Feedback on Using Cognitive Strategies of Problem Solving

In interactive computer assisted instruction, feedback may assist the learner to discover effective cognitive strategies of problem solving. Computer based feedback may present only the amount and type of information that assists the learner in identifying the relevant cues and relationships in a problem, and in selecting effective procedural rules for solving the problem. It may also enhance the development and use of cognitive skills that guide the learner in selecting and organizing effective rules to regulate and monitor deductions made toward the solution of the problem (Gagne, 1985; Gagne & Briggs, 1979; Gallini, 1985; Kozma, 1986; Tennyson, 1986).

Nevertheless, the effect of computer based feedback on the learner's development and use of effective cognitive strategies of problem solving has not been directly explored. Exploring this effect could guide the design and development of effective instruction in problem solving. It could, moreover, explain the contradictory results of the effect of feedback on learning.

Rigney (1978) identified four basic categories of techniques in automated instructional systems that may enhance the development and organization of the learner's cognitive processes. They are: 1) orienting tasks or directions that induce the learner, either directly or indirectly, to perform specific operations, 2) content bridges or material that is specific to a particular subject matter, 3) cognitive strategies that facilitate the acquisition, retention, and retrieval of subject matter, and that are initiated by the learner or the instructional system, and 4) knowledge of results. Rigney, however, did not specify how knowledge of results acts by itself, or how it interacts with the other elements in the system, to facilitate learning.

On the other hand, Kulhavy (1977) reviewed the literature on feedback used in written instructional material searching for an explanation of the contradictory findings of feedback research. He concluded that feedback following a correct response would be effective as it confirms the learner's "comprehension strategies" i.e., it informs the learner that his/her strategies helped achieve the goal. Feedback will be even more effective after an incorrect response as it allows the learner to identify the error, and under appropriate conditions, correct that error.

Research evidence suggested to Kulhavy that feedback is ineffective in two instances. The first is when the learner is unable to comprehend the instruction and fit it in an existing cognitive framework. In this instance the learner keeps guessing at the answer and trying to arbitrarily associate a response with a correct answer. The second instance is when the feedback is available to the learner before he/she responds, an instance that is avoidable in computer assisted instruction.

In line with the conclusions Kulhavy drew from the feedback research, Rumelhart & Norman (1978) stated that feedback may affect the learner's cognitive operations in one of three ways. It may: (1) confirm a correct answer and thus lead to the addition of new information to existing schemata and strategies, (2) tune the existing schemata and strategies by pointing to minor errors that need correction, or (3) point to major errors in the learner's schemata and strategies, and guide the learner in restructuring them, which is a difficult and time consuming task.

The above theory works on the assumption that feedback confirms definite cognitive frameworks and strategies. However, in computer assisted problem solving there are cases when feedback is designed to confirm correct solutions to problems regardless of the cognitive strategies the learner follows to arrive to the solutions. The learner could arrive to the same solutions using different cognitive strategies, or no clear strategies.

Consequently, feedback in problem solving instruction may be: 1) solution oriented, as when it informs the learner whether the product of a mathematical problem—for example—is correct or incorrect regardless of the procedures and cognitive strategies used to arrive to the product, and 2) strategy oriented, as when it informs the learner whether the cues and relationships he/she identifies in a problem are relevant and correct, whether the rules he/she follows are appropriate, and whether his/her way of organizing and applying the rules is efficient.

Moreover, the effect of feedback may interact with the cognitive strategies the learner develops before the instruction. In other words, the effect of feedback does not only depend on whether the feedback is strategy oriented or solution oriented, but also on whether the learner is using certain cognitive strategies in the first place. Consequently, solution feedback may unintendedly and indirectly confirm or not confirm the cognitive strategies the learner is using. Figure.1 represents the predicted interaction between feedback and the learner cognitive strategies.

INSERT FIGURE 1 ABOUT HERE

Figure 1 shows that feedback may increase, decrease, or not affect performance in a problem solving situation. The effect of feedback depends on: 1) the function of feedback (strategy oriented or solution oriented), and 2) whether the feedback confirms or does not confirm~~s~~ the cognitive strategies the learner is using.

Evidence from research suggests an interactive effect between feedback and the learner's possible use of cognitive strategies. Boysen, 1980; Isham, 1980; and Renzi, 1974 found that field-dependent subjects benefited from explanation feedback more than field-independent subjects. Since field-dependent subjects are inclined to respond to the environment in a global rather than an analytical way, they may also be less inclined to develop and use cognitive strategies in problematic situations. Field-dependent subjects are therefore expected to benefit more from feedback as it helps them identify relevant features and relationships in a problem, and helps them select or develop appropriate procedures and cognitive strategies.

Contrary to the above findings, Boysen & Thomas (1980) found that field-dependent subjects benefited more from "implicit feedback" while field-independent subjects benefited more from "explicit feedback". The subjects' task was to practice solving linear equations. Impilicit feedback showed subjects how to perform operations they requested regardless of whether these operations were relevant or irrelevant to the problem at hand. Explicit feedback showed subjects how to perform the operations they requested only when the operations were relevant to the problem. If the operations requested were irrelevant, the subjects were shown the relevant operations.

As the experimenters noted, a field-dependent subject could have benefited from the analytical operations provided by the impilicit feedback. On the other hand, field -independent subjects could have been testing strategies through explicit feedback. Had explicit feedback been given to field- dependent subjects through force order instruction, they probably would have performed better receiving explicit rather than implicit feedback.

Cognitive strategies could be an intermediate variable responsible for the unexpected results of feedback found by Spock (1987). The performance of undergraduate students instructed in BASIC did not vary when they received explanatory feedback from the performance of others who received knowledge of results feedback. However, the results did indicate that subjects with prior knowledge benefited more from explanatory feedback. Since prior knowledge is an indicator of the availability of cognitive frameworks and strategies (Larkin, McDermott, Simon, & Simon, 1980), those subjects may have been able to improve their frameworks and/or strategies as they received explanatory feedback.

Johnson & Plake (1977) found that graduate students performed better when they received feedback after each step they made in the analysis of variance. Similarly, Roper (1977) found that the performance of undergraduate students in statistics was superior when they received feedback that stated the correct answer compared to their performance when they received feedback that simply indicated whether their response was correct or incorrect.

The purpose of the present study was to investigate the effect of strategy feedback and solution feedback on developing and using cognitive strategies of problem solving. The effect of this variable was studied as it interacted with the learner's cognitive strategies.

Strategy feedback was given to the subjects throughout instruction on problem solving. The feedback informed them whether their responses to the features of a problem, the relationships between the features, and the procedures they followed to solve the problem were correct or incorrect. The feedback also indicated what the correct responses were, and why. Solution feedback was given to the subjects only as they solved practice problems to inform them whether a solution to a problem was correct or incorrect, and what the correct solution was.

Strategy feedback and solution feedback either confirmed or did not confirm the subject's cognitive strategies. This was done by measuring the cognitive strategies the subjects used to solve problems prior to the instruction, then instructing them on strategies that were either similar to, or different from the cognitive strategies they used.

Two dependent variables were used. They were: 1) the number of problems solved correctly within a limited time on a posttest, and 2) the number of the subjects who shifted to a better choice on a questionnaire designed to measure the strategies they used to solve pretest and posttest problems.

The following hypotheses were tested:

1. The performance of the subjects who receive strategy feedback that confirms their strategies will be superior to the performance of the subjects who receive solution feedback that indirectly confirms their strategies.
2. The performance of the subjects who receive strategy feedback that confirms their strategies will be superior to the performance of the subjects who receive strategy feedback that does not confirm their strategies.
3. The performance of the subjects who receive solution feedback will be superior to the performance of the subjects who receive strategy feedback that does not confirm their strategies.
4. The performance of the subjects who receive solution feedback that indirectly confirms their strategies will be superior to the performance of the subjects who receive solution feedback that does not confirm their strategies.
5. More subjects will modify their cognitive strategies when they receive strategy feedback than when they receive solution feedback.

METHOD

Subjects:

The subjects were 65 volunteer udergraduate students, males and females, enrolled in three sections of a computer literacy class at the University of Texas at Austin. The subjects were assigned randomly to four groups, corresponding to the four cells of a 2*2 factorial design.

Pilot Study:

A pilot study was conducted on 32 students drawn from a fourth section of the same computer literacy class. The main purpose of the pilot study was to determine whether the students used cognitive strategies to solve the type of problems used in the study, and if they did, what kind of strategies. The materials and measurments developed for the main study were used in the pilot study. The results of the pilot study indicated that 30 out of the 32 students used spatial cognitive strategies to solve the problems. A ceiling effect was also detected. Appropriate changes were thus made in the materials and procedures.

Materials:

Instructional Content: Instructional content was selected to be generic problem solving. Three-term series problems were used. An example of the problems is:

Sandy is taller than Wanda.
Wanda is taller than Albert.
Who is the tallest?

There are 8 different determinate structures to this problem. For each of these structures, two problems may be formulated: (1) one problem when the final question asks for the largest term, and (2) the second problem when the final question asks for the smallest term. Consequently, a total of 16 problems could be constructed using the same terms and comparatives. Countless problems, however, could be constructed using different terms and comparatives.

In the present study, the names of males and females were used as terms. Different verbs and comparatives were also used to avoid the repetition of the problems, and to relate them to events familiar to the subjects.

Since three-term series problems are logical problems, valid inferences are drawn from their premises. A rule of inference is essentially syntactic in nature i.e., it dictates what can be drawn from expressions on the bases of their forms regardless of their meaning (Johnson -Laird, 1985). Evidence from research indicates that college students solved three-term series problems using spatial cognitive strategies (De Soto, London, and Handle, 1965; Huttenlocher, 1968). In addition, some students discovered the perceptual features of the problem and developed perceptual strategies to solve them. (Johnson-Laird & Bara, 1984; Quinton & Follows, 1975). The perceptual strategies enabled the subjects to solve the problems without forming the series, and with a minimal load to the working memory. As a result, the subjects who used percptual strategies took significantly less time to solve the problems than those who used spatial strategies.

In the present study, four computer programs were developed. The four programs gave identical instruction on the features of the problems and the relationships between the features. Two out of the four programs gave instruction on spatial strategies to solve the problems, while the other two programs gave instruction on perceptual strategies to solve the same problems. The instruction on the strategies was followed with identical practice problems.

The method of instruction in the four programs was the guided discovery method, as outlined by Collins (1985). Forty two questions were posed systematically in each program to guide the learner to relevant aspects of the problem, and to the thinking skills needed to solve the problems when following either spatial or perceptual strategies.

One spatial strategies program and one perceptual strategies program gave strategy oriented feedback, while the other two programs gave solution oriented feedback. The strategy feedback indicated to the subjects, after each response to the forty two questions in the program, whether the response was correct or incorrect. If the response was correct the subjects were still informed of the correct answer, and of why the answer was considered correct. If the response was incorrect, the cues relevant to the answer were highighted for the subjects and they were asked to try again. The subjects were informed after the second try if the response was correct or incorrect, informed of the correct answer, and of why the answer was considered correct.

The solution feedback was given to the subjects after solving the practice problems only. The subjects were informed whether their solution was correct or incorrect and were asked to try again. The subjects were then informed whether their second try was correct or incorrect, and of the correct solution.

Measurment Of Problem Solving: Sixty four three-term series problems were designed after the 16 possible determinant problem structures, four for each structure. Thirty two of these problems were used as a pretest and the other 32 as a posttest. The pretest and the posttest problems were matched.

Measurement Of Cognitive Strategies: A questionnaire was developed to measure the cognitive strategies the subjects used to solve both the pretest and the posttest problems. The questionnaire consisted of 20 multiple choice items and one short answer item. Eight of the multiple choice items were about the features of the problems and the relationships between the features. Six items were about the spatial strategies, and the remaining 6 items were about the perceptual strategies. There was a better answer to each item. The better answer reflected the most efficient way to solve the problems. The short answer item asked the subjects to list mental tricks, strategies, rules, or steps they followed in their mind as they solved the problems.

Procedure:

The experiment was conducted in two sessions. During the first session, each subject in a section of the computer literacy class was instructed to solve the 32 problems of the pretest as quickly and accurately as possible, without using any materials such as paper and pencil, and without using his/her hands or fingers to figure the solution. The instructions informed the subject that he/she would have 7 minutes to solve the problems, and that the computer would stop presenting the items when the time was up.

At the end of the test, the subjects were shown the number of correct responses, and were asked to answer the questionnaire. The computer recorded the subjects' correct responses on the pretest.

During the second session, a week later, the subjects followed similar procedures, only this time they went through one of the four instructional programs before the posttest. In addition, the programs cued the subjects to enter the time they started the instruction and the time they finished it.The computer recorded the subjects' correct responses during the instruction and during the posttest.

The tests and instruction were administered via an Apple 11E computer. They were written using Super Pilot.

Design:

A 2 * 2 between subjects factorial design was employed, the factors being: 1) feedback, strategy oriented or solution oriented; and 2) the cognitive strategies the feedback confirmed, spatial strategies or perceptual strategies. The spatial strategies were similar to the subjects' cognitive strategies, while the perceptual strategies were different from the subjects cognitive strategies.

RESULTS

Table 1 shows the means and standard deviations of the 4 treatment groups for the pretest and the posttest scores, the time spent in receiving the instruction (in minutes), and the number of correct responses during the instruction.

INSERT TABLE 1 ABOUT HERE

The means were higher in the posttest than the pretest, while the standard deviations were lower. The median of the entire sample on the pretest was 29.00 out of a possible score of 32, and the range was 19. The median was raised to a score of 31 in the posttest, with a range of 14.

Pearson correlation coefficients were calculated between pretest scores, posttest scores, treatment duration, and number of correct responses during the treatment. Significant positive correlations were found between posttest scores and pretest scores (coefficient = .52, n = 65, p = .000), and between posttest scores and number of correct responses during treatment (coefficient = .30, n = 64, p<.01). A significant positive correlation was also found between treatment duration and number of correct responses during treatment, (coefficient = .40, n = 57, p = .001).

Spearman-Brown test of reliability was conducted on the 6 items of the questionnaire that measured Ss cognitive spatial strategies, and on the 6 items that measured their cognitive perceptual strategies using the split half method. The reliability coefficients were .89 and .66, respectively.

Prior to performing ANCOVA, the assumption of homogeniety of regression was tested for the posttest as a dependent variable and the pretest as a covariate. The test was nonsignificant (p>.32), indicating that homogeniety of regression was tenable. Table 2 reports the results of ANCOVA.

INSERT TABLE 2 ABOUT HERE

Table 2 shows that the main effects of both factors were nonsignificant. However, there was a significant feedback by strategy interaction F(1,60) = 4.22, p = .04. The interaction is illustrated in Figure 2.

INSERT FIGURE 2 ABOUT HERE

Figure 2 shows that strategy feedback was more effective when it confirmed strategies that were similar to the subjects' cognitive strategies i.e., spatial strategies, than when it confirmed strategies that were different from the subjects' cognitive strategies i.e., perceptual strategies. The adjusted means were 30.52 and 28.59, respectively. Conversely, solution feedback was more effective when it confirmed the perceptual strategies (adjusted mean = 30.16) rather than the spatial strategies (adjusted mean = 29.37).

Chi squares were conducted on each item of the questionnaire to find out the effect of the four treatments on the number of subjects who shifted to a better choice. Significant differences were found with respect to 4 items only. Chi squares were then conducted to investigate the effect of strategy feedback versus solution feedback on the number of subjects who indicated that they changed the strategies they used after the instruction from those they used prior to the instruction. The Chi square was significant (Chi square = 3.90, df = 1, *p* = .05)

DISCUSSION

The purpose of the study was to examine the effects of solution oriented and strategy oriented feedback. The feedback confirmed problem solving strategies that were either similar to the learner's cognitive strategies (spatial strategies), or different from the learner's cognitive strategies (perceptual strategies). The dependent variables were: 1) the number of problems the learners solved correctly within a limited time, and 2) the number of learners who shifted to better choices on a questionnaire designed to measure their cognitive strategies.

When the learners were instructed on the spatial strategies, strategy feedback was more effective than solution feedback. The results suggest that feedback given throughout the instructon on problem solving modifies the learner's cognitive strategies only if the~~se~~ strategies in the instruction are similar—to some extent—to the learner's cognitive strategies. These results support the notion of a corrective (Kulhavy, 1977), or tuning (Rumelhart & Norman, 1978) effect of feedback on cognitive frameworks and strategies. The results are also consistant with the findings of Johnson & Plake, 1977; Roper, 1977; & Spock, 1987.

On the other hand, strategy feedback was less effective in learning perceptual strategies than in learning spatial strategies. Moreover, strategy feedback was less effective than solution feedback in learning the perceptual strategies. That 'more' feedback may have no effect (Kulhavy, 1977), or an adverse effect (Rumelhart & Norman, 1978) when the instruction tries to develop different or difficult frameworks and/or strategies is also supported by research evidence (Gilman, 1969; Merrill, 1985; Schoen, 1972; Spock, 1987; & Steinberg, 1980).

Comparing the results of the interaction detected in the study with the predicted interaction illustrated in figure 1, we find that the predicted effects of strategy feedback are confirmed. That solution feedback would be less effective than strategy feedback when the learner is instructed in strategies that are similar to his/her own cognitive strategies is also confirmed. The unpredicted results, however, are the positive effect of solution feedback on learning strategies that are different from the learner's cognitive strategies.

It may be noted that the instructional method used in the study was the guided discovery method. The entire information given to the subjects was in the form of questions. The subjects were to find the answers to those questions by observing examples of the problems. The process of guiding the learner into discovering features, relationships, and rules; and of organizing the rules to efficiently solve the problems, was gradual. It is plausible that providing feedback during the process of discovering the new perceptual strategies was interrupting to the flow needed for this process. Solution feedback during practice may have confirmed the strategies the learners were able to discover on their own during acquistion. Merrill (1985) cited evidence for the effectiveness of questions on discovery learning, and for the ineffectiveness of feedback during the discovery process. More research is needed to compare the effect of feedback during the processes of strategy acquistion and practice.

It is speculated that the ineffectiveness of strategy feedback in learning strategies that are different from the learner's cognitive strategies may be apparent only during the preliminary stages of learning. However, as the learner starts to reconstruct his/her cognitive strategies and starts testing them, feedback may assume its corrective function. In the present study, more learners indicated a change in the cognitive strategies they used to solve the posttest problems. Research is needed to compare the effect of strategy feedback, and solution feedback at different stages of an extended instruction. Similar research is also needed to compare feedback effects on learners with low and high problem solving skills, on learners with clear cut and unclear cognitive strategies, and on learners who are confident or are not confident in the efficiency of their cognitive strategies.

It is of interest to note that the two major types of strategies used to solve three term-series problems—spatial and perceptual—were reported in studies using different problem solving tasks (Greeno, 1978; Larkin et al., 1980; Wood & Shotter, 1973). Reseach is needed to find out if the effect of training in one type of strategies or the other transferes to different problem solving tasks.

Since problem solving strategies are learnable, and since the cognitive strategies the learner develops may not be efficient, more computer assisted instruction is needed in this area. Instruction on strategies of problem solving would be based on measures of the learner's cognitive strategies. A choice of strategy feedback or solution feedback would depend on the efficiency of the learner's cognitive strategies, and on whether the strategies to be learned are similar to, or different from the learner's cognitive strategies.

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Table 1.
Means and Standard Deviations of the Four Treatment Groups

Treatment	Pretest	Posttest	Time	Correct During Instruction
Solution Feedback, Spatial Strategies (n = 13)	27.60 (3.67)	29.92 (2.94)	14.46 (3.39)	34.54 (3.10)
Solution Feedback, Perceptual Strategies (n = 16)	24.56 (5.59)	29.81 (2.43)	14.43 (3.52)	33.81 (4.64)
Strategy Feedback, Spatial Strategies (n = 17)	26.18 (4.95)	30.65 (1.19)	18.57 (2.58)	37.81 (1.84)
Strategy Feedback, Perceptual Strategies (n = 19)	24.63 (5.96)	28.26 (4.43)	22.53 (3.91)	36.42 (2.74)
Total Mean (n = 65) Standard Deviation	25.62 (5.39)	29.60 (3.13)	17.40 (5.13)	35.73 (3.61)

Note:Maximum score = 32 for each test, 42 for instruction.

Table 2.
Anaysis of Covariance for Posttest

Source	SS	df	MS	F	Sig. Level
Within Cells	417.32	60	6.96		
Covariate	155.61	1	155.61	22.37	.000
Feedback	.70	1	.70	.10	.75
Strategies	4.85	1	4.85	.70	.41
Feedback*Strategies	29.36	1	29.36	4.22	.04

Figure Captions

Figure 1. Predicted Interaction Between Feedback and the Learner's Cognitive Strategies.
Figure 2. The Interaction Between Feedback and the Strategies it Confirmed.

Fig. 1.

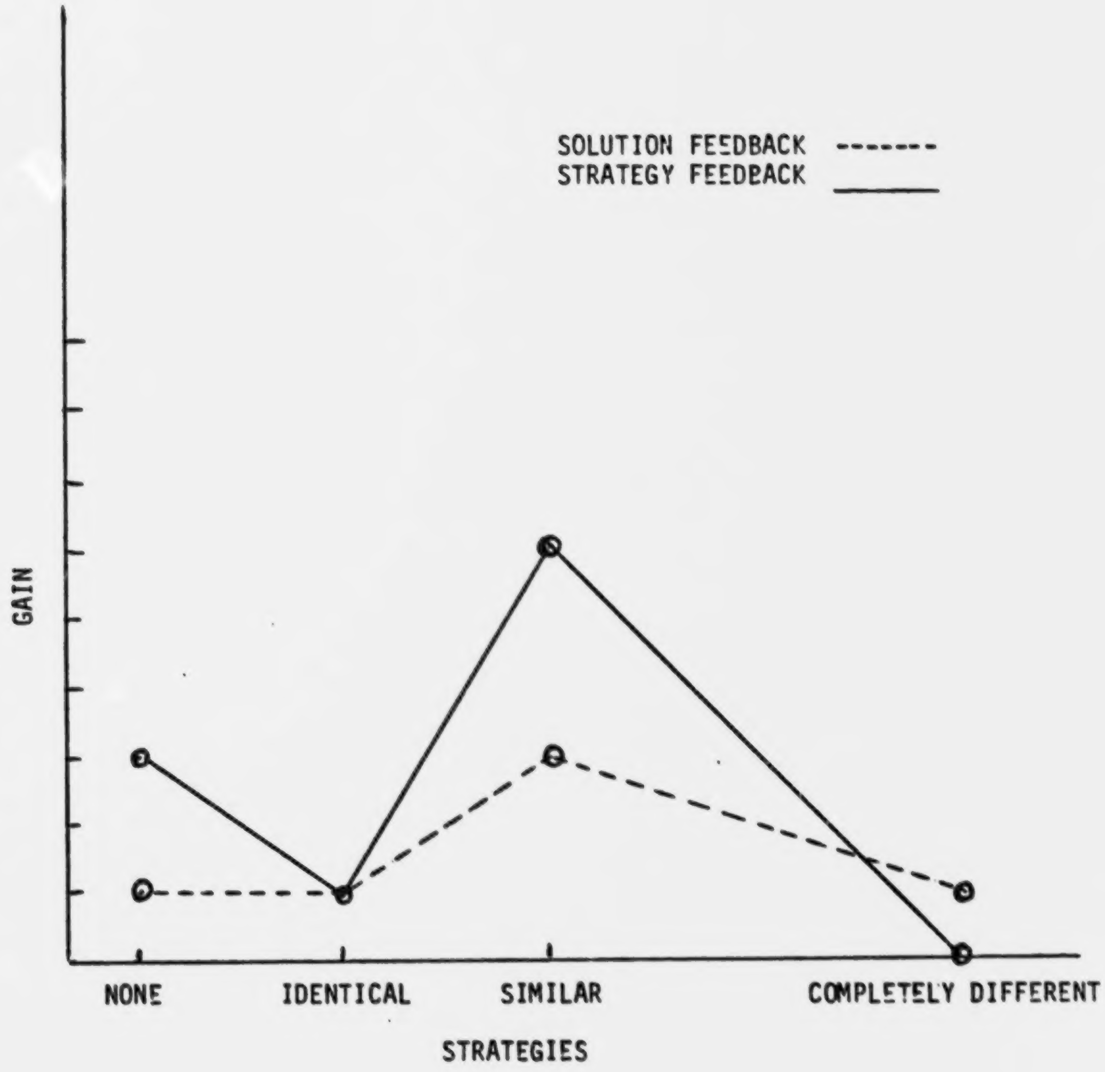
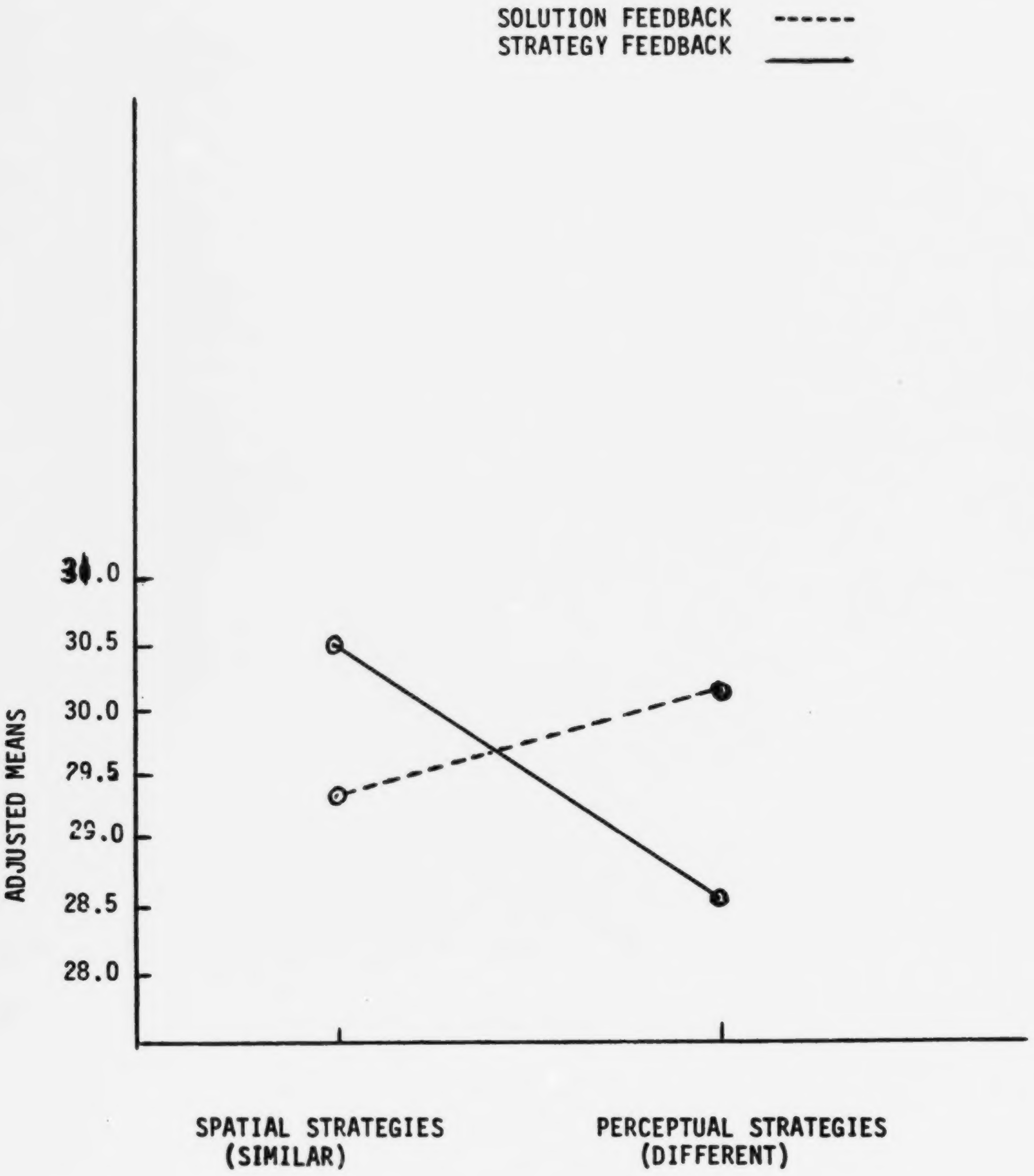

SOLUTION FEEDBACK -------
STRATEGY FEEDBACK ______
GAIN
NONE
IDENTICAL
SIMILAR
COMPLETELY DIFFERENT
STRATEGIES

Fig 2


SOLUTION FEEDBACK ------
STRATEGY FEEDBACK ——
ADJUSTED MEANS
31.0
30.5
30.0
29.5
29.0
28.5
28.0
SPATIAL STRATEGIES (SIMILAR)
PERCEPTUAL STRATEGIES (DIFFERENT)

Title:

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Constructing Mental Representations of Complex Three-Dimensional Objects

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With the advent of the information processing paradigm, researchers interested in human learning often consider how strategies used in programming computers are analogous to certain mental functions. Drawing on this computer metaphor, scientists at MIT's media lab, including Alan Kay and Seymour Papert, are designing instructional strategies for using computers to expand mental functions and cognitive flexibility (Brand, 1987). Instructional approaches supported by Kay and Papert focus on the development of parallel mental processes used to recognize patterns and construct relationships in the visual mode. The progress that the MIT group has made, with the computer-enriched environment at the Hennigan grade school in Boston, indicates that this "right brain" approach to instruction may offers a viable alternative to the more linear approaches used in traditional language-driven instruction.

Many of the strategies for using computer graphics to develop constructive mental processes focus on the acquisition of cognitive abilities by depicting stages of a concept or event in an iconic or pictorial format. The icons used in this type of instruction attempt to replicate what the objects or events would look like from the natural perspective while the relationships between the concepts are depicted as consequence rather than process. Thus, the learners are left with the task of comprehending abstract relationships which may not fit into their cognitive schemata.

An alternative approach is to identify valid cognitive processes and design displays which elicit affiliated perceptual processes through tasks which require mediation of relationships which resemble those involved in the targeted cognitive process. Once elicited, these perceptual processes might be used to facilitate transfer to the targeted cognitive processes.

Psychobiographies of noted intellectuals (Shepard, 1978; Hadamard, 1945) suggest that the ability to mentally construct images which possess three-dimensional properties can contribute to creative thinking. For example, in describing the thought processes he used in developing "The Special Theory of Relativity," Einstein explained that he mentally constructed images of various objects while imagining he was traveling at the speed of light. When what he observed did not coincide with existing theory, he was left with the task of systematically converting what he had "seen" into mathematical expressions. Thus, the ingenuity of Einstein's discovery was more dependent on his ability to form abstract mental representations of an idealized world than on his expertise in mathematics.

Einstein's imaging ability could not have been based entirely on environmental equivalents, because no such equivalents exist. Instead, it required a novel construction of mental representations on the basis of anticipated changes in spatiotemporal information. Mediated displays, which require the learner to employ such processes at the perceptual level, might facilitate the development of these spatiotemporal processes and thereby contribute to creative thinking. This study focuses on the nature of the processes involved in forming mental representations from different methods of depicting complex three-dimensional objects on two-dimensional surfaces.

Media techniques for representing the interior of objects, on the limited two-dimensional surfaces of a sheet of paper or video screen, have primarily been based on the perception principles we use to identify objects in the real world. By combining orthographic projection with surface renderings, color and shadowing techniques, artists can depict the exterior of objects as transparent; thereby revealing various interior sub-components. With the addition of computer animation, these three-dimensional depictions become more convincing when the objects are shown as rotating in space. However, even when computer animation is used, surface based depictions can not adequately represent all the interior components of more complex objects such as the brain or the geological structure of the earth.

A commonly used technique for depicting the interiors of more complex objects is to present the object as a sequence of cross-sections or slices. In neuroanatomy, brain slices are individually stained and converted to diagrams which are presented in succession on the pages of an atlas. The atlas technique requires that each diagram have a separate orienting procedure indicating the slicing axis and the location or depth from which the cross-section was taken. While some learners are capable of using the atlas technique to construct meaningful images, many others learners have difficulty integrating the procedures for mentally combining the individual cross-sections. A technique which uses computer graphics to display the cross-sections in continuous succession may provide a more effective means for developing abilities to form mental representations of three-dimensional objects with complex interiors.

The processes under investigation are those which influence the construction of mental representations from a sequence of cross-sections depicting a three-dimensional object traveling in a continuous path through a two-dimensional plane (see Figure 1). The viewer of this dimensional travel display must therefore construct a mental representation, which possesses three-dimensional properties, on the basis of changes which occur in two dimensions over time. Unlike the atlas technique, the dimensional travel technique provides the opportunity of constructing the three-dimensional mental representation directly from the stimuli. The perceiver can act on the incoming information immediately without relying later on strategies for reconstructing a three-dimensional image from a series of memorial representations. Thus, although the processes involved in dimensional travel may resemble cognitive imagery processes, they are considered perceptual.

Generalizing Dimensional Travel to Affiliated Cognitive Processes

According to supporters of central theories of perception (Fleming, 1987; Rock, 1983; Norberg, 1978; Gregory, 1977), individuals actively construct percepts from several sources of information including the information available in the external world, internal feedback and previous experience. Central theories assume that there is a reciprocal interaction between perception and cognition. As new information is acquired it alters the structure of internal cognitive schemata which in turn influences the way new information is analyzed. Norberg (1966, 1978) and Salomon (1981) have argued that central theories are more viable guides for instructional research because they assume perception is a constructive process that can be controlled by the viewer and not just a direct apprehension of some pre-existent reality.

In addition to providing a new means of conceptualizing the interior of complex objects, the processes acquired during the viewing of the dimensional travel displays may serve to elicit cognitive imagery skills. Piaget and Inhelder, contended that perceptual observations serve as precursors to higher order cognitive processes. For example, Piaget (1966a) claimed that a child's ability to anticipate the height that a given amount of liquid will reach when poured from a narrow to a wide glass (anticipatory imagery) is in part dependent on the child having observed similar transformations of liquids in the natural world. This ability to mentally manipulate perceptual-like or analog mental images has also been linked to development of memory (Paivio, 1976; Bower, 1972), reasoning skills (Kaufmann 1979; Piaget & Inhelder, 1971; Bruner, Olver & Greenfeld 1966) and creative thinking (Finke, 1980; Shepard 1978; Hadamard, 1945).

Potential Difficulties in Solving the Dimensional Travel Task

This study is exploratory. It is designed to investigate some of the strategies which different learners use in constructing mental representations from the dimensional travel display. The shape and complexity of both the objects displayed and the distractors selected for the forced-choice alternatives have been designed to reveal difficulties which learners may have in forming mental representations of various types of objects presented with the dimensional travel display.

The participants in this study see two different techniques for depicting three-dimensional objects on a two-dimensional surface. One method is the dimensional travel display which is a dynamic depiction of the surfaces of the objects and their interior components. The second method is the traditional orthographic procedure using perspective, hidden lines, surface transparency and shadowing to depict the objects and their interior components in a static mode. (Figure 2 shows the static displays of the forced-choice alternatives used for the dimensional travel display depicted in Figure 1). Thus, the recognition task requires the subject to first construct a mental representation of the three-dimensional object based on observing the dimensional travel display, store the mental representation in memory and then decode it in order to identify the correct option from the orthographic projections of the forced-choice alternatives.

Studies of anorthoscopic (abnormally viewed) perception (Aust, 1984; Rock, 1983) have found that simple and familiar figures are more easily recognized than complex and unfamiliar figures. Anorthoscopic perception refers to the ability to recognize figures as they pass behind a narrow stationary slit. Recognition of anorthoscopically presented figures can be considered as a problem of recovering a two-dimensional figure from the motion information which takes place along a one-dimensional slit. The assumption is that the familiar figures assist the viewer in establishing hypothesis for constructing the mental representations. Thus, when objects are presented with the dimensional travel technique, the simple objects should be more easily recognized than the complex objects. However, there is no evidence which indicates which aspects of object complexity present the most difficulty in mediating a dimensional travel display.

The shapes depicted in this study were all regular three-dimensional translucent solids: spheres, pyramids, cubes, cylinders, rectangular solids and a rotated rectangular solid described as a diamond. The complexity of the objects was based on the number of internal solids that the objects contained, the degree of embeddedness and the shape of the solids. Five levels of object complexity were identified. The simplest level, coded O-O, was a medium sized solid embedded in the center of a larger solid. The next level of difficulty, coded O-O/O, was two adjacent medium sized solids both embedded in a larger solid. The third level, coded O-O-O, was a small solid embedded in the center of a medium sized solid which was embedded in the center of a still larger solid. The fourth level, coded O-O/O-O, was a small solid embedded in a medium solid which was adjacent to another medium sized solid, all of which were embedded in a larger solid.

The most difficult level of object complexity, coded O-C/D, was based primarily on shape differences (see Figure 3). All of the objects in this level were embedded in the center of a rectangular solid. The internal solids in these objects were cylinders and the diamond solids. The diamonds were actually rectangular solids which were rotated so that the facing surfaces were 90 degrees from the facing surfaces of the larger rectangular solid. The interior solids were all the same length and height with a horizontal length equivalent to the horizontal length of the larger rectangular solid. They were oriented so that their horizontal center lines were parallel to the facing square of the larger rectangular solid in which they were embedded. Thus, the horizontal center line of the cylinder was parallel to the slicing plane. In this orientation, the cross-sections of the diamond solids are very similar to the cross-sections of the cylinders. The primary difference relates to the relative depth of the cross-sections.

When the cylinder first appears in the display, the cross sectional view shows a somewhat wider band than the diamond shaped object. This is because a greater portion of the cylinder's surface is tangent to the slicing plane. If the cross-sections produced by the diamond solid and cylinder are compared as they move through the slicing plane, the height of the respective rectangles increase at a different rate. When the diamond solid passes through the slicing plane, the resulting rectangle increases at a constant until it reaches the maximum height and then decreases at a constant rate until the solid has passed through the slicing plane. When the cylinder passes through the slicing plane, the change in the rectangle's height is initially rapid. The change slows down as the maximum diameter is reached and finally increases again before the cylinder passes completely through the slicing plane.

The differences between the way the cylinder and diamond shape appear as they pass through the dimensional travel display are subtle. However, they are crucial to understanding the spatiotemporal processes required in mediating the display and may reveal a preference for either the spatial or temporal component. Learners who have difficulty identifying the difference between the two displays may have similar problems in recognizing sequential differences in an atlas of the brain or cross-sections of geological structures. Deficiencies in mediating these spatiotemporal differences might serve as guides for redesigning presentation strategies which begin with the obvious and progressively move to more subtle distinctions.

Mental Representations Formed in Solving the Dimensional Travel Task

Studies of the ability to mentally rotate figures (Shepard & Metzler, 1971) have found that the time it takes to recognize a rotated figure is an analog of the number of degrees the figure has been rotated. These studies provide evidence that the subjects were mentally rotating visual images of the figures. Other evidence for the construction of visual mental representations has been found in studies of anorthoscopic perception (Aust,1984; Rock, 1983). When a target is introduced in an anorthoscopic display to indicate the speed at which a figure is moving behind a slit while the actual figure speed remains constant, the length of the perceived figure increases with each decrease in the target's speed and decreases with each increase in the target's speed. Thus, the nature of the constructed percept, which many subjects reported "seeing," was influenced by the both spatial components as revealed through the slit and the temporal components indicated by the speed of the moving target.

The dimensional travel task is in some ways similar to both the mental rotation and the anorthoscopic perception tasks. The orienting processes used to determine the axis of the object in relation to the slicing plane are similar to the orienting processes required in the mental rotation task; while the ability to mentally construct dimensional properties on the basis of a sequence of slices is similar to the anorthoscopic perception task. If subjects who view the dimensional travel display report that they see faint copies of the three-dimensional objects, this would indicate that they immediately formed a perceptual-like mental representation. If, on the other hand, they report using a verbal mnemonic strategy, some level of propositional coding would be indicated.

Another way of investigating the nature of the mental representations, formed while viewing the dimensional travel display, is to look at what type of errors are made. Subjects who rely on a verbal coding strategy for remembering the internal components of the objects may be more likely to make errors in the embeddedness or order of the object's sub-components. This is because they must first decode the icons from the dimensional travel display into a verbal mnemonic (e.g. square inside triangle inside circle), remember the verbal sequence and then decode the verbal sequence in identifying the correct orthographic projection. On the other hand, subjects who rely on a visual/holistic encoding strategy would be less likely to make an order error because such errors usually represent a radical change in the visual structure of the object.

For example, if the object presented in the dimensional travel display is the option which appears at the top center of Figure 4, the option at the bottom center is one of the order errors (both object are made up of a cube, two pyramids and a sphere). A viewer who uses a verbal code to remember the sequence of objects components and then rearranges the sequence during storage or recall, might consider this a viable alternative. However, if the viewer relies entirely on a visual/holistic strategy for storage and recall, this order error seems much less viable because the visual structure is radically different from the correct option. The visual/holistic viewer's errors are more likely to be represented by the position error at the top right of Figure 4 which is a rotation of the correct option.

Sex Differences in Visual-Spatial Abilities

The assumption that males perform better than females on some tests of visual spatial ability has been supported by several researchers (Conner & Serbin, 1977, 1985; Lohman, 1986; Maccoby & Jacklin, 1974; McGee, 1979). Some investigators (Maccoby, 1966; Maccoby and Jacklin 1974) have found that the most marked differences in spatial visualization appear after the onset of puberty. These studies suggest that differences in spatial ability may be, at least in part, attributable to biological gender differences. Others (Conner & Serbin, 1985; Gagnon, 1985), have found that training in visual-spatial skills benefits females more than males which suggests social or environmental factors. Research which focuses on specific visual-spatial abilities, such as those required in mediating the dimensional travel display, may yield strategies to accommodate for sex differences or adjust possible sex bias in instructional procedures.

METHOD

Subjects

Student volunteers were 10 males and 31 females (mean age of 24.1) who were enrolled in education classes at the University of Kansas.

The Dimensional Travel Display

A Silicon Graphics IRIS computer was used to create the dimensional travel displays of the three-dimensional objects. Mathematical models were created for each of the objects using the graphics tools which are part of the IRIS system software. The objects and sub-components were rendered as shells with white surfaces. A blue opaque plane was positioned so that its axis was parallel to the front of the monitor's screen. When an object was presented in the dimensional travel display it was initially positioned behind the opaque field. The object was then directed along the Z axis so that, as it passed through the slicing plane, the outline of the object's surfaces appeared as thin lines. The result was a dynamic depiction of a white three-dimensional object passing through a blue field. The monitors in Figure 1 accurately depict proportions.

A meter, designed to indicate the depth of the object in the slicing plane, was positioned at the bottom of the screen. As an object passed through the slicing plane a red bar moved along the meter indicating the object's depth along the Z axis.

Once the graphics had been created on the IRIS system they were transferred to videotape using a Silicon Graphics genlock board and a Lenco sync generator/encoder. The videotape, which was edited for testing, began with an orientation segment showing a wire frame three-dimensional object passing through a two-dimensional field while the function of the meter was demonstrated. The orientation segment concluded with a sample item which was representative of the dimensional travel objects presented during the testing phase.

The testing phase of the videotape consisted of dimensional travel displays of 30 objects (5 difficulty levels X 6 objects). Each dimensional travel display was preceded by a 3 second warning that the "Object is Arriving," and concluded with a 5 second countdown during which the words "Identify Object" appeared on the screen.

The Forced-Choice Alternatives

Orthographic projections of the objects presented in the dimensional travel display and the alternative objects were created using Super Paint software on an Apple Macintosh II computer. Shadowing techniques, hidden lines, and surface transparency were used to create convincing depictions of the three-dimensional objects. The object renderings were then incorporated in a Hypercard program.

The Hypercard program began with a segment which complemented the orientation phase of the videotape. A scenario describing how the objects had been lost in space and needed to be recovered was created in order to assist the subjects in developing the hypothesis that three-dimensional objects would pass through a two dimensional plane described as "the detector field." The scenario explained that it was their task to identify the correct object from amongst the alternative which would be presented on the computer monitor as soon as the object had passed through the detector field.

Each of the response screens included six forced-choice alternatives - one correct response and five distractors. The distractors were selected to represent three different types of errors: shape, position and order. Shape errors were ones in which at least one of the solids which composed the objects was of a different shape from any of the solids depicted in the corresponding dimensional travel display of the object. Position errors were ones in which all solids were of the same shape but the position of the internal solids was reversed. Order errors were when the level of embeddedness and size of the solids was reversed but the shape and number of the solids was the same. The distractors were counterbalanced so that there was an equal number of shape, position and order errors (50 each) for the thirty objects.

Procedures

Each subject was individually tested by either a male or female observer. The videotape was presented on a 13" video monitor which was located to the right of and directly adjacent to the computer monitor. The observer prepared the videotape and Hypercard program and led the subject through the orientation phase. A question and answer period was provided both before and after the subject saw the sample item. When the subject agreed that the task was understood, testing began.

During testing the computer monitor showed a "Wait to Identify Object" screen while the video monitor depicted the first dimensional travel object. As soon as the object had passed through the detector field on the video monitor the observer advanced the computer program to display the forced-choice alternatives. The subject was allowed five seconds to select one of the six objects which appeared on the computer screen. The observer positioned the pointer on the subject's selection and pressed the mouse which automatically recorded the subject's response and advanced the program to the next "Wait to Identify Object" screen. This procedure was repeated for the remaining 29 objects.

An informal question and answer discussion followed the collection of quantitative data. The subject were asked questions such as: "How did you remember which object had passed through the detector field? Did you actually see the object as it passed through the detector field? Did you use the meter to help you see the object? Explain what you saw when you watched the objects pass through the detector field."

Analysis

The T-Test procedure found in the SPSS software package was used to compare the ability of males and females to correctly identify the objects at each difficulty level. A summary of the means appears in Table 1. Differences were not significant at any of the difficulty levels. A review of the means indicates that, at least at this adult age, females may have no more difficulty than males in identifying the objects presented with the dimensional travel display.

Because the alternatives used for each of the object levels were different, tests of significance were not used to compare the error types or object difficulty levels. References to means are used as general indicators of performance. The mean number of correct responses for all object levels ($\underline{M}$= 4.67 out of 6 possible) indicated that the subjects were capable of recognizing many of the objects presented with the dimensional travel display. There was a possible tendency to make shape errors ($\underline{M}$= .86) over order ($\underline{M}$= .24) or position ($\underline{M}$= .22) errors. However, this trend was primarily a reflection of the responses to difficulty level five objects. When the errors made on the first four object difficulty levels are compared, the small difference between the mean shape ($\underline{M}$= .03), order ($\underline{M}$= .18) and position ($\underline{M}$= .27) errors did not suggest a tendency.

The means in Table 1 provide a general indication that as the previously identified object difficulty level increased, the ability to recognize the correct object decreased. The most marked decrease in ability to correctly identify the object occurred at difficulty level five. The level five objects were the ones in which the subjects had to differentiate between the cylinder and the diamond shape solids. At level five, the subjects selected more of the shape distractors ($\underline{M}$= 4.20) than they did the correct responses ($\underline{M}$= 1.25). This result could reflect random guessing because there were four shape distractors for each item at this difficulty level.

The mean number of correct responses for the first four difficulty levels was 5.52 out of the 6 possible for each category. This indicates that adult learners were able to recognize most of the objects presented with the dimensional travel display when the shape of the interior solids was sufficiently different so as not to require extensive reliance on the temporal component. That is, when the object could be differentiated from the alternatives on the basis of remembering the outlines in a few representative slices, the subjects were more likely to identify the correct alternative. Whereas, when the orientation and shape of the components within the objects produced dimensional travel displays which differed primarily by the rate at which the outlines were revealed, the subjects were less likely to identify the correct object.

The assumption that the subjects relied more heavily on the spatial component than on the temporal component was also evident in their descriptions of how they solved the task. Out the 41 participants, 26 specifically reported using internal verbalization strategies for remembering the structure of the objects. A typical comment was, "I remembered the shapes from left to right. I would say circle, triangle, square or whatever and then I would look for them in the shapes on the computer." Other subjects reported a similar verbal strategy except that they remembered the objects from the outside to the inside. When these subjects were then asked to explain how they remembered the position of the shapes they would typically say they also internally verbalized the shapes from left to right. The subjects who relied on internal verbalization rarely reported using the meter for anything more than to tell when the object was about to leave the detector field.

A few of the subjects reported using psychomotor representations of the objects' components. One of these subjects explained, "When I saw a circle on the outside I would make a circle with my first two fingers and then the next shape with my next finger ... I put the shapes on the left in my left hand and the shapes on the right in my right hand." One subject reported using a combination of internal verbalization and psychomotor representation. She explained that she would say the shapes to herself and then tilt her head in the direction of the shapes.

Only 7 of the 41 subjects specifically reported forming iconic images of the objects while viewing the dimensional travel display. These subject typically said they made a picture of the object in their mind and then looked for the picture on the computer screen.

One girl, who responded correctly to all of the options, explained, "After I saw the first one (the sample), I decided to make a picture of the shapes in my mind. I'm good at that kind of thing but I'm glad the first ones were easy because it took awhile for me to get the hang of it....The ones with the cylinders and stuff were the hardest but after I got it, I could just see the detector field go around the edges." When asked if she used the meter in any way she replied, "Well I didn't watch it directly but I think I was using it subconsciously... I'm glad it was there. I think it helped me see the objects."

Discussion and Recommendations

Because advances in microcomputer technology have only recently made this method of presenting three-dimensional objects practical in instructional settings, there were no existing guidelines for using the dimensional travel technique to depict complex objects or enhance abstract visualization skills. Nor was there evidence to indicate which type of learners would have success or difficulty in mediating the dimensional travel display.

Other studies have found that males perform better than females on many tests of visual/spatial ability. The difference between males and females was not evident in this study. Perhaps the spatiotemporal skills required in mediating this type of display are sufficiently different from the skills required for the static tests commonly used to assess visual processing. Another possibility is that proficiency in internal verbalization, which many of the subjects reported using, may have offset any deficiency in encoding or decoding the visual components. However, these conclusions are tentative because of the limited sample size and similar research using larger sample sizes, which are balanced for males and females, is recommended.

Differences in ability to mediate the dimensional travel display may also occur at different developmental levels. Several researchers (Cooper & Shepard, 1973; Piaget & Inhelder, 1971; Rohwer, 1970; Shepard & Podgorny, 1978), have contended that the ability to construct and transform mental representations increases with age. A previous study (Aust, 1984), which addressed spatiotemporal processes similar to those required for the dimensional travel task, found that anorthoscopic perception followed a developmental trend. Findings from this study, especially those which relate to the selection of objects and orientation of the slicing plane, will be used to refine the procedures in making the display appropriate for a younger population. Further studies with a younger population could lead to a developmental approach for training in spatiotemporal processing ability.

The most difficult aspect of mediating a dimensional travel displays involves the analysis of the temporal component. If the goal is to explicitly reveal the interior components of complex three-dimensional objects to the broadest range of learners, the primary factor in determining the orientation of the slicing plane should be based on differences in the shapes revealed as opposed to differences in the temporal component or rate of revelation. For example, the cylinder and diamond solids would have probably been recognized by a broader range of subjects if the objects had been rotated 90 degrees along the horizontal axis so that the slicing plane reveals a circle and diamond. Another procedure, which is presently used with some medical technologies such as MRI or CAT scans, is to reveal the same three-dimensional object using several different slicing orientations.

However, a different set of recommendations are in order if the instructional goals extend beyond simply revealing the interior of objects to the development of abstract reasoning skills in spatiotemporal processing. One instructional strategy might begin with displays of objects which focus primarily on the spatial component and gradually move to displays which require more temporal analysis. This strategy could be augmented by moving from exercises, in which the alternatives are presented while the object is being revealed, to exercises which require the student to remember what has been displayed before seeing the alternatives.

The students could also be asked to generate drawings of the objects presented in the dimensional travel display, either with paper and pencil or with computer drawing programs. Another possibility is to provide three-dimensional transparent objects and have students make a sequence of drawings to represent what the object would look like as it travels through the detector field.

One of the outcomes of the computer revolution has been to make us aware of the complexity and intellectual sophistication of our perceptual abilities. Computer scientists have created machines capable of remarkable feats in storing, retrieving and manipulating both graphic and verbal/mathematical information. However, despite numerous challenges, they have been unable to create a computer capable of reliably differentiating a dog from a cat (Brand, 1987). Could this mean that the seed of human ingenuity is rooted more deeply in our perceptual abilities than we have previously recognized?

Paper based instructional support materials have led to a reliance on verbal/mathematical systems for teaching reasoning skills - possibly because it was less expensive and faster to present ideas in words and numbers than it was to produce pictures, icons or animated depictions. As we move from paper based to electronic based instructional support materials, students will be able to access a greater variety and amount of information in much less time than they have in the past. However, they will not be adequately prepared to enter the third wave information society by simply applying a linear approach in consuming more and more information. They must be able to select relevant information, see novel relationships between diverse concepts and invent new strategies for combining a variety of information forms in constructing meaningful wholes.

Continued research, which yields insights into the way we construct meaning at the perceptual level, will assist in developing sound foundation for addressing these abstract reasoning skills. A more comprehensive plan for enhancing perceptual abilities may result from this research. But teachers can begin now by recognizing the importance of perceptual abilities while selecting materials and developing activities which encourage students to discover original ways to perceive their world.

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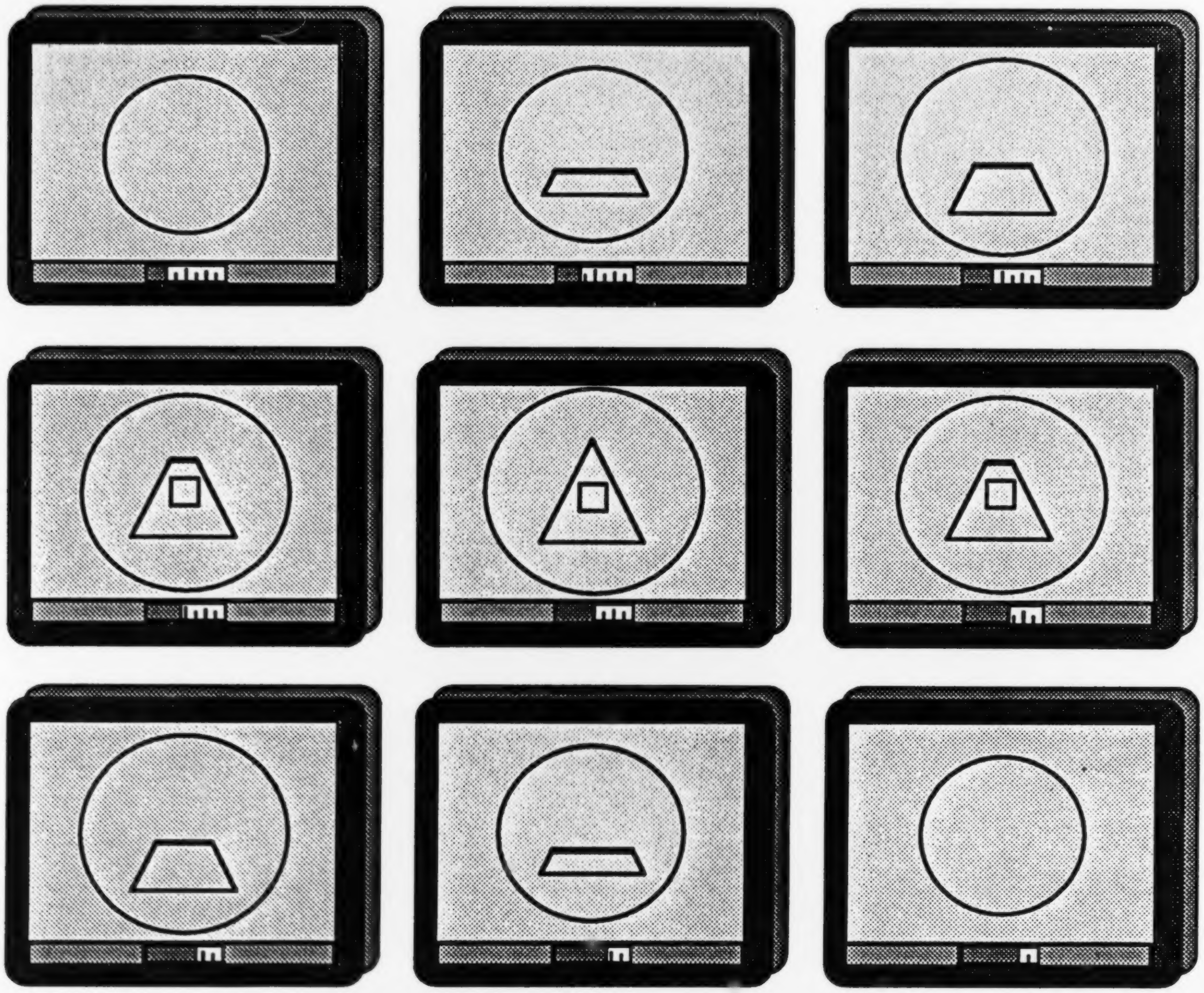
Figure 1

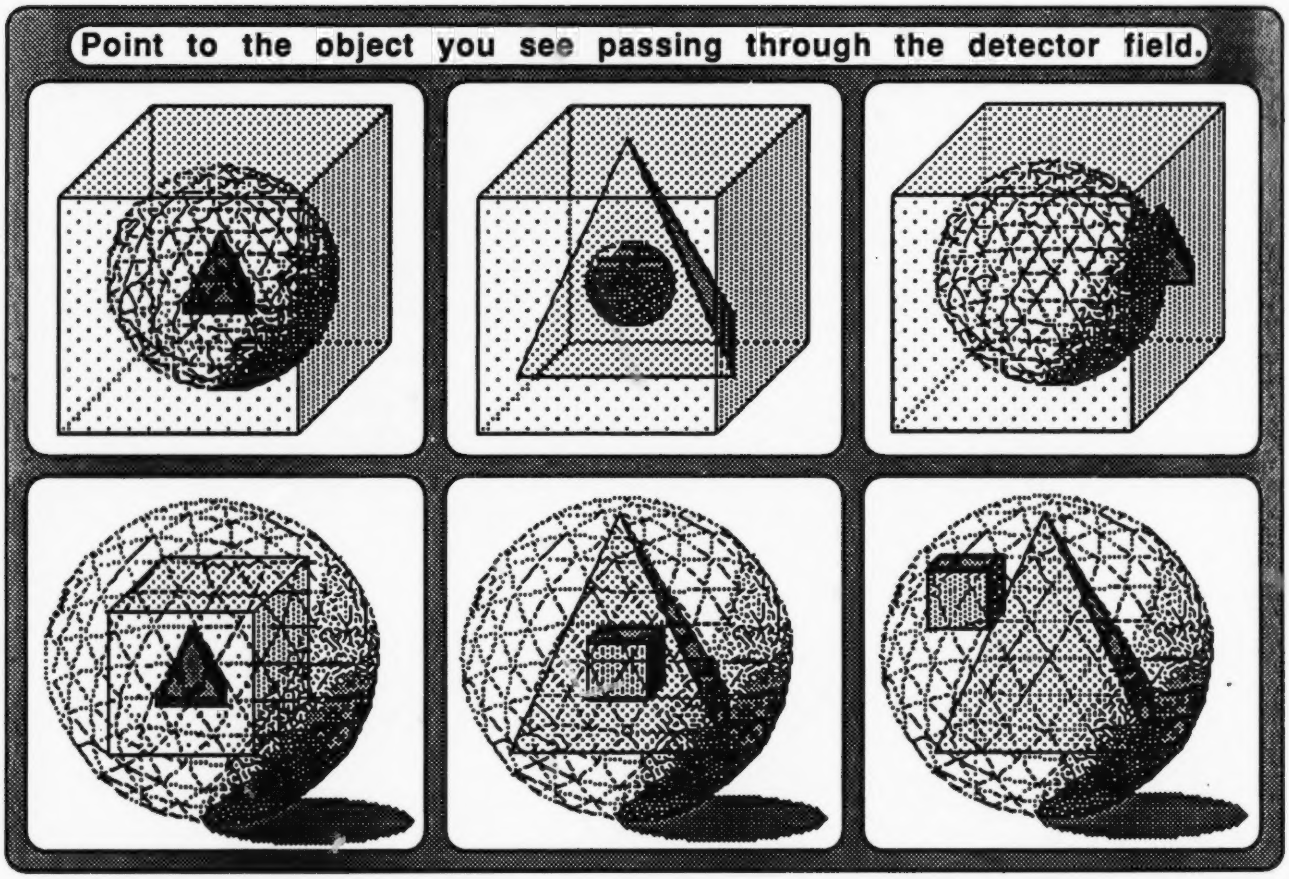
Dimensional Travel Display of a
Cube Inside a Pyramid Inside a Sphere



The above figures show one of the thirty object as it travels through the dectector field. The meter at the bottom of each screen indicates the distance that the object has passed through the screen. In this case the three-dimensional object which is passsing through the screen is a cube inside a pyramid inside a sphere.

Figure 2

The Forced-Choice Alternatives for the Dimensional Travel Display Depicted in Figure 1



Point to the object you see passing through the detector field.

Figure 3

The Forced-Choice Alternatives for the Level Five Objects

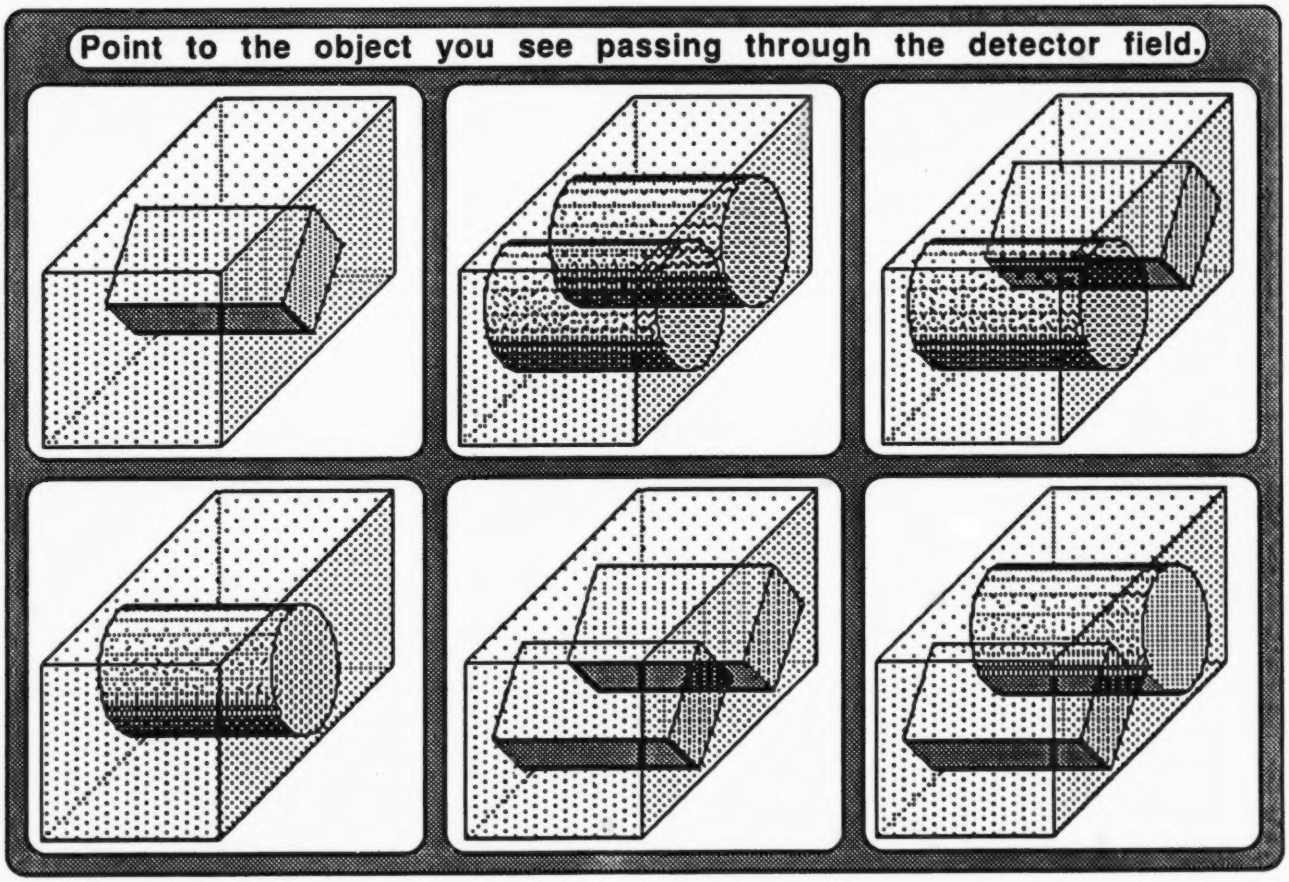
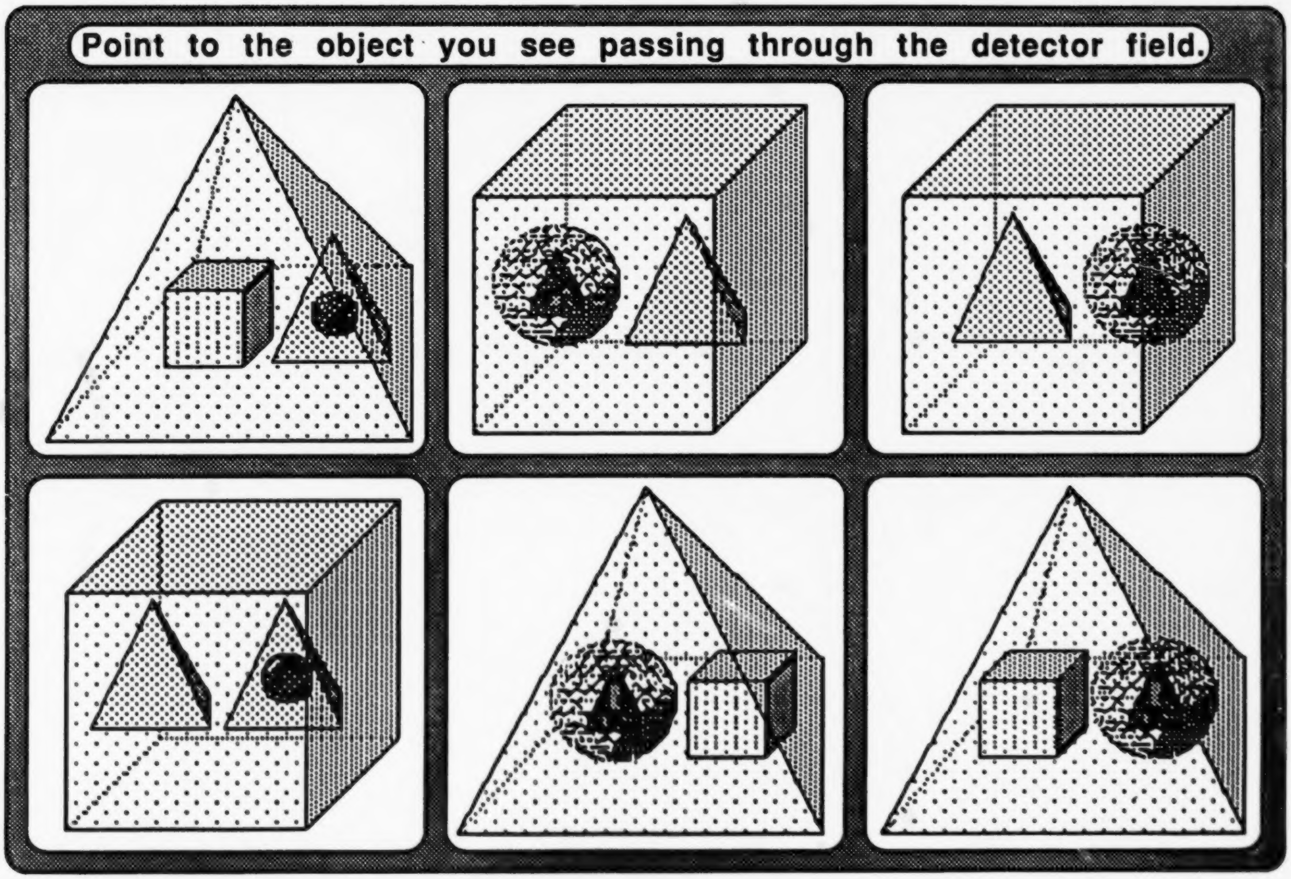

Point to the object you see passing through the detector field.

Figure 4

Possible Order and Position Errors


Point to the object you see passing through the detector field.

Top row	order error	correct response	position error
Bottom row	order error	order error	order error

Table 1.

Mean Error Types X Object Complexity X Sex

	Correct		Error Types: Shape		Error Types: Order		Error Types: Position	
	M	F	M	F	M	F	M	F
O-O	5.80	5.81	.10	.09	.10	.09	.00	.00
O-O/O	5.70	5.77	.00	.03	.00	.03	.30	.16
O-O-O	5.60	5.67	.00	.00	.40	.19	.00	.12
O-O/O-0	4.80	5.00	.00	.00	.30	.29	.90	.70
O-C/D	1.30	1.19	4.10	4.30	.60	.42	.00	.00
Totals X Sex	4.64	4.69	.84	.88	.28	.20	.24	.20
Totals All	4.67		.86		.24		.22	

Level 1 (O-O) ---- A medium sized solid embedded in the center of a larger solid.

Level 2 (O-O/O) ---Two adjacent medium sized solids both embedded inside a larger solid.

Level 3 (O-O-O) ---A small solid embedded in the center of a medium sized solid, which are both embedded in a larger solid.

Level 4 (O-O/O-O) -A small solid embedded in a medium solid which is adjacent to another medium solid, all of which are embedded inside a larger solid.

Level 5 (O-C/D)----Cylinders and diamond solids embedded inside of a larger rectangular solid.

Title:

SYMPOSIUM: Technological Equity: Issues in Ethics & Theory

Chairperson: John C. Belland

Paper #1	Richard Howell
Paper #2	Suzanne K. Damarin
Paper #3	Patti R. Baker John C. Belland
Paper #4	Randall G. Nichols
Paper #5	William D. Taylor James D. Swartz
Paper #6	Barbara L. Martin

SYMPOSIUM

Technological Equity: Issues in Ethics & Theory

Annual Meeting
Assoiciation for Educational Communications and Technology
New Orleans, LA
January 17, 1988

John C. Belland, The Ohio State University, Chairperson

Presenters

William D. Taylor, The Ohio State University
James Swartz, The Ohio State University
Richard Howell, The Ohio State University
Suzanne K. Damarin, The Ohio State University
Patti R. Baker, Battelle Memorial Institute
John C. Belland, The Ohio State University
Randall G. Nichols, The University of Cincinnati
Barbara Martin, Kent State University

As technological processes and products become more pervasive in education and society, it is becoming increasingly apparent that the benefits of educational technology are often distributed unequally and that individual and social-group differences can inhibit access to the technology which is available. Research and development in educational technology ordinarily seeks to predict and measure some benefit for learners from the use of technology. Such research and application efforts may actually increase the differences between the "haves" and the "have nots."

This symposium grew out of a series of conversations among the presenters about their ongoing research. Each appeared to the others to be working on aspects of using technology to address some social "imbalance" or to investigate the effects of technology which might inadvertantly create such an "imbalance." Some of the issues identified included: creating technological dependency, imposing male or majority-group values on women and minorities, and ignoring subtile effects of communications technology. The papers raise questions rather than provide answers

Title:

SYMPOSIUM: Technological Equity: Issues in Ethics & Theory

Paper #1 The Ethics of Technological Intervention with Disabled Learners

Author: Richard Howell

The Ethics of Technological Intervention with Disabled Learners

Richard Howell, Ph.D., The Ohio State University

The advent of what has come to be known as "new technologies" has served to open up new avenues for communication, mobility and physical interaction by disabled individuals. As these avenues have become increasingly defined and made available, the level of personal independence of the disabled user has evidenced a commensurate increase. But technological advances do not occur in a vacuum, they occur within a particular milieu and time. Such movements tend to take place in societies that have both wealth and a social concience; places where technological impetus can be directed toward more "humanistic" goals. But no society can insure that progress will occur, or even that such "progress" is in the appropriate direction! The disparity in societal goals, limited willingness to engage energy and resources, and the general public's lack of knowledge about disabled persons' needs cause progress in designing and developing technological answers for the disabled to be sporadic and lacking overall direction.

A groundswell of activity in special education and rehabilitation engineering has developed a wide variety of assistive devices and computer software designed to meet the needs of an even wider assemblage of handicapped users. In the midst of the burgeoning research and development activities comes an opportunity to re-examine the ethical implications of interventions using such devices in the delivery of instruction. It is important that ethical issues be included in the continuing dialog between the instructional design community and those involved with the education of disabled learners. There are several perspectives concerning the appropriate strategies required in order to design and develop quality instruction for disabled learners. Some viewpoints are associated with the perspective of the needs of the "dominant" culture in relation to a special interest subgroup; and others from the perspective of a disabled individual with abilities that can be enhanced by computer- or video-based instruction. Regardless of the perspective taken, each one imposes requirements and limitations on the design, development and implementation of assistive devices and software for the disabled.

The purpose of this paper is to discuss a few of the more pressing ethical issues associated with technological interventions and disabled learners. The issues raised are speculative in nature and are meant to encourage further questioning rather than to pose solutions to immediate or potential problems. Many of the issues are the result of questions raised in the design of research being conducted at the Ohio State University. This research is investigating the use of robotic manipulators on the cognitive and affective skills and abilities of severely orthopedically handicapped children. Our efforts to analyze some of the cognitive and affective demands associated with technological interventions has led to a sobering realization of the extreme limitations imposed on researchers by unreliable and expensive assistive devices, problems with accessing these devices, and difficulties in training teachers, therapists and students to use the devices. The discussion that follows looks at a few key issues involving the role of the instructional designer in the process, presents a proposed model for designing technological interventions for the disabled, and some final comments.

Is Technology a One-Way Street?

There are some basic conflicts between the goals and needs of any society and those of its minority, or special needs, groups. One conflict involving the disabled and the larger population of non-handicapped individuals arises from the fact that most technological devices are designed and built with the physically-able person in mind. This bias permeates all aspects of the design process, evidencing itself in restricted access from the exterior of the device, and limitations within the device that make it difficult for it to be adapted for disabled users. Vanderheiden (1983) makes a reasoned plea for technological "curb cuts" similiar to those in our streets that have gradually been employed to allow greater access by wheelchair users. He advocates: 1) the initial consideration of potential disabled users in the design phase of equipment development, and 2) the incorporation of adaptive design features at the "circuit-board" level of production. This would allow for both immediate access to available peripherals and for future peripheral attachments, board expansions or display adaptations necessary for a variety of disabled users. Shworles (1983), a quadriplegic rehabilitation consultant, cautions us that, "The vast numbers of people with disabilities, the extreme variability from one disability condition to the another, and the complexity and fast-changing nature of the computer industry, when viewed all together, reminds us that the national challenge making computers accessible is only beginning to be done and could fall far short of being a job well done." (p. 325).

Realizing Hopes and Dashing Dreams.

The presence and use of computers, video, and even robots with disabled learners has evidenced modest, but generally positive, results in use with a variety of handicapping conditions, ranging from the mildly handicapped (Hasselbring, 1987), to the severely orthopedically handicapped (Leifer, 1983; Howell, Damarin, & Post, 1987). However, these initial successes belie the difficult and costly developmental effort that went into each hardware or software innovation. They also do not encompass the even larger number of studies showing no significant effects, studies which were never reported, or pilot programs; all of whose findings are valuable for the field but are never disseminated on a national basis.

Another serious limitation of computers and other technologies involves the length of time it will take for some innovations to reach the marketplace and the even longer time for many of the devices to become affordable. These cautions should also be addressed in discussions of potential benefits accruing to the devices in order to add perspective to the real costs of developing and adapting devices for use with the disabled.

The Instructional Designer and the Disabled User

There is a surprising congruence between the conceptual foundations that underlie Instructional Systems Design Theory (Gagne, 1985) and accepted philosophy and practices in special education. Such critical features of the instructional design process as the identification of needs, the specification of individual goals and objectives, and the formative and summative evaluation of progress are also critical features of special education practices.

However, a similarity in processes does not guarantee a mutuality of perspectives concerning the importance of the individual in the learning process. In fact, it is all too easy to minimize or even forget the user in the design process once the needs assessment has been completed. Too often, the results of the assessments become isolated pieces of data in the design process that eventually have little to do with the reality of the changing person.

Maintaining an awareness of both the cognitive and affective dimensions of behavior is considered to be crucial to the development of all instructional products, and has been found to be important in the development of effective computerized instructional software (Damarin, 1987). However, even the most optimal design will always be a reflection of certain assumptions about the nature of learning, the role of the learner and teacher, and the integration of materials via the technological delivery systems. These assumptions almost always take the form of generalizations when they are operationalized into an educational product that is meant to be used by more than one individual. Thus, the more information the designer has about the characteristics of the target population(s), including psychomotor, cognitive and affective information, the more appropriate the technolgoical intervention will be for use by a variety of disabled learners.

Designing with the Disabled in Mind

Burkman (1987) has recently proposed a "user-oriented instructional design" process that attempts to incorporate the opinions, perceptions, and acceptance of the users of the instructional materials. This model, if applied with a few modifications, might reasonably meet the needs of the disabled learner. The model is presented below and includes proposed additions specific to the disabled learner. Burkman views the Potential Adopter of the planned product as "the instructors who would use the product"; the modified procedure appearing here presents the Potential Adopter as a disabled user of the planned product/technology.

Step 1: Identify the Potential Adopter (PA). Who would be affected by the planned product if it was to be adopted? What is the range of disabled individuals who can potentially use the product?

Step 2: Measure Relevant Potential Adopter Perceptions. Includes: 1) how PA's perceive that the instruction should be done, 2) the attributes of instructional products that they perceive to be important, 3) the specific aspects of physical control and communicative abilities of the learner brings to the task?

Step 3: Design and Develop a User-Friendly Product. This includes the use of the instructional design procedures developed by Gagne (1985) with two modifications:

1. The designer attempts to incorporate as many of the attributes that are valued by the PA and tries to make the presence of the attributes as apparent as possible.

2. Evaluative criteria are expanded to include the degree to which the PA: 1) perceives the product favorably, and 2) tends to adopt it and implement it effectively.

Step 4: Inform the Potential Developer. Once the product has been developed, inform any potential developers about the product, stressing its user-valued attributes.

Step 5: Provide Post-adoption Support. Once adoption has occurred, the teacher or instructor must be given the tools needed to implement the product.

Instructional tools developed through processes similiar to Burkman's must also evidence certain characteristics in order to be useful to a broad range of disabled persons. In general, they should be: 1) ***adaptable and accessible*** to a range of student users, 2) ***facilitate and enable*** cognitive, affective and psychomotor growth on the part of the students, 3) ***affordable,*** in terms of financial and logistical costs (includes training and maintenance considerations), 4) ***flexible*** enough to allow for continual refinement when subjected to formative and summative evaluations.

Summary

The points expressed in this article illustrate the dichotomous reality of contemporary United States society which promises equal access but tenders only grudging acceptance of its disabled members. It is clear that disabled individuals and their non-disabled proponents must work hard to maintain progress that has been won in the past and move forward as their energy and resources allow. Forward to a future that is bright only if the design, development, and utilization of enabling technologies are seen as "tools for independence and expression". To be used by the disabled person and not for them.

The Instructional Designer's role is one which commonly reflects the values and mores of the larger culture and yet must also transcend the limitations that come with designing for the majority. This requires first of all, a sensitivity to the needs, attitudes and desires of the disabled among us. Secondly, a willingness to adapt and change procedures or materials to accomodate the needs of the disabled user. Finally, it demands that the designer maintain a constant awareness of the disabled users among the potential base of users of their products.

In summary, while the process of education continues to evolve with the use of new technological systems, the basic need for individual acceptance and respect of the disabled learner should remain within the focus of the instructional designer. The process of bringing about the changes necessary for greater independence to the disabled is not soley within the purview of the instructional design community, but their ability to contribute is evident. Their training and skills provide a compatible match to those of the special education and therapeutic communities and together can provide a new level of cooperation in developing acceptable technological answers for use by the disabled learner.

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Title:

SYMPOSIUM: Technological Equity: Issues in Ethics & Theory

Paper #2 Issues of Gender and Computer Assisted Instruction

Author: Suzanne K. Damarin

Issues of Gender and Computer Assisted Instruction

Suzanne K. Damarin, The Ohio State University

The purpose of this paper is to examine strands of research on the education of girls and women, and to analyze implications for the design of computer-based instructional systems. The education of girls and women has been studied from the perspectives of sex differences, gender differences, and Feminist studies; the differences in these perspectives are important to the interpretation of findings.

The Education of Girls and Women

Research on *sex differences* is based upon an assumption of biological determinism (and often an assumption of female inferiority). These studies focus upon the measurement and genetic explanation of differences; their findings tend to be interpreted to educators as expectations for achievement, rather than as prescriptive in any sense. Current research in this tradition is typified by the work of Benbow and Stanley (1980, 1983).

By contrast to sex differences research, research on *gender differences* and education is based on a recognition that *gender* is a social construct associated with, but not identical with, the biological fact of sex. Therefore, researchers on gender differences attend not only to the manifestations of cognitive abilities, but also to social phenomena in the classroom, experiential differences between girls and boys, attitudinal and emotional differences, and the relationships between and among these phenomena. A few examples from the numerous findings of this research are: (1) overt and subtle sexism in classroom materials, (2) differences in the amount and type of teacher feedback, (3) differences in attitudes of students and their significant others, (4) differences in math anxiety, (5) differences in optimal learning setting, and (6) the description and supplantation of cognitive effects of early experience.

While researchers in the traditions of sex differences and gender differences differ in their willingness to accept ability as biological and immutable, they share a willingness to accept the content of school learning. *Feminist educational research* is based upon a rejection of this assumption; researchers working from the feminist perspective see the content of school instruction as masculine in that it has been determined by male values, experiences, and intellect. Therefore, feminist educators study biases within the selection, ordering, and interpretation of topics of instruction, the confounding of the cognitive and affective domains in instructional materials and evaluative techniques, and even the definition of fields of study (e.g., "History = What men have done in public." Bezucha, 1985, p. 84).

It should be noted that many feminists would probably consider Instructional Design, itself, to be a masculine discipline, which incorporates male values by insisting on analytic approaches, orientation towards goals rather than processes, and, in Turkle's (1984) term "hard mastery" criteria for success.

Defining Gender-Fair ICAI

Intelligent Computer Assisted Instruction (ICAI) provides a model through which to examine more carefully the issues summarized above. ICAI (also know as Intelligent Tutoring Systems (ITS) is chosen for this analysis because, at least theoretically, it incorporates both the existing models for computer instruction and the promised models of the future. Most ICAI schema show the system as composed of four modules, each communicating with the others (Rambally, 1986; Wenger 1987). These modules are:

Domain Knowledge	This module is an "expert" on the knowledge that is to be communicated. It provides both a source of knowledge and a standard against which to evaluate student knowledge. It can engage in dialogue concerning the content as well as criterion referenced measurement of student knowledge.
Student Model	Like domain knowledge, this module is an expert system. Ideally the model includes knowledge of all aspects of the student's behavior and knowledge that have implications for performance and learning. It is sometimes called the diagnostic module.
Pedagogical Knowledge	Also an expert system, this module is responsible for decisions concerning the presentation of material (e.g., branching, frames); it includes knowledge of pedagogical principles which are applied to information communicated to it from the Domain Knowledge and Student Model modules.
Interface	This module is responsible for communication between the pedagogical module and the student. It translates machine information into a form understood by the student and vice-versa.

Each of the modules gathers information from those listed before it; thus, in some sense, they are listed in order of importance to designers. The question addressed below is the implications of research on women for these modules; a comparable question can, and should be asked in relation to each of the minority groups in society.

The sex differences perspective. Research from this perspective is based upon an assumption of fixed and value-free content and yields replicated differences between the sexes in mathematical, verbal, and spatial abilities, as well as in aggressiveness; several other variables of potential difference have been explored with mixed results (Maccoby and Jacklin, 1974; Fausto-Sterling, 1985). Attention to improving the mathematics instruction of girls and women by adoption of this point of view requires that these variables be addressed in the development of ICAI as follows:

Knowledge Domain:	Sex is irrelevant to the content and to its organization.
Student Model:	Sex is relevant to student performance and must be a part of the model.
Pedagogical Knowledge:	Aggressiveness required of student may be relevant to the selection of appropriate teaching strategies.
Interface:	Use of verbal, symbolic, or spatial representation of knowledge may be differentially appropriate to students based upon sex.

The major implications for instructional designers lie in the area of needed research, and that research would appear to lie largely in the direction of "how can expert systems incorporate teaching and communication strategies which are maximally effective for girls?"

The gender differences perspective. The implications of gender differences research for ICAI are considerably more complex, in part because they affect the Knowledge Domain. This research has implications for both the selection and organization of information, and for other elements of ICAI as follows:

Knowledge Domain:	(1) Expand the content domain to include information relevant to women's learning. (2) Contract the content to exclude sexist examples. (3) Organize the content to allow more diverse modes of querying.
Student Model:	Sex of student is a relevant variable and has interactions with attitudes, anxiety, motivation, encouragement from significant others, which are also relevant variables.
Pedagogical Knowledge:	Include strategies for cooperative learning, at least at the level of concept development. Eliminate sexism from examples.
Interface:	No clear implications.

The findings from research on gender and ethnic differences in learning are quite complex in their implications for construction of a Knowledge Domain and a Student Model. Different lines of gender research suggest the addition of spatial information, historical information, metacognitive strategies, and metamathematical advice to the Knowledge Domain; addition of these types of information would require different, and perhaps conflicting, organizations of knowledge.

An argument can be made that (human) teachers call upon at least two content relevant Knowledge domains: knowledge *of* the content and knowledge *about* the content. The latter domain includes such information as the prevalence of particular errors, a typology of errors, referents to knowledge outside the given domain, useful analogies, miscellaneous motivational ideas, jokes, etc. The logic underlying access and use of Knowledge *about* mathematics is entirely different from the deductive logic *of* mathematics. Perhaps, if ICAI is to be made responsive to issues raised by researchers on gender and mathematics, it must be conceptualized as having two Knowledge Domains: *Knowledge of Mathematics* and *Knowledge about Mathematics*.

Regardless of whether and how information *about* mathematics is included in ICAI, there remains the question of how the information *of* mathematics should be organized in a Knowledge Domain. Researchers on children's play suggest that boys and girls build different cognitive structures based upon their play activities, and that these structures are differentially useful for organizing mathematical information. Studies of Native American children (Garbe, 1973) and of Oriental graduate students (Damarin and West, 1979) indicate the existence of cultural differences in the relative importance of particular concepts to students in full or partial command of a body of mathematics. Damarin (in prep.) provides a rationale for expecting some similar differences between male and female children as they study fractions. The implication of these studies is that the organization of concepts in ICAI must be fluid rather than fixed, giving learners the opportunity to structure their own knowledge in a manner consistent with their own linguistic and cognitive structures.

The challenges posed for ICAI designers by research on gender differences are fundamental to the design of the Knowledge Domain. Gender differences research also has implications for the Student Model and the Pedagogical Knowledge modules. Some of these implications are demands for research; little is known, for example, about how math anxiety interacts with subject matter specifics, nor about how one would use anxiety information to modify instruction. The finding that girls learn initial concepts more effectively in cooperative learning settings (Fennema and Peterson, 1986), raises a constellation of questions for ICAI.

It should also be noted that, because the computer can be dispassionate, ICAI could be quite useful in correcting some gender-based inequalities in education. Girls and boys should expect equal amounts of task relevant feedback, and both should work with examples which are not laden with sexist connotation.

The Feminist Perspective. The attempt to bring together ideas from feminist educational theory and an advanced model for instructional design is, perhaps, tantamount to heresy in both fields. Nonetheless, the generality claimed for the ICAI model by educational computing enthusiasts, and the ubiquity of male influence, as elaborated by feminist researchers, invites a joint analysis of these positions. A preliminary summary of implications of feminist theory for the elements of the ICAI model is as follows:

Knowledge Domain:	Knowledge is never value-free: content and organization of this domain should allow querying of values. Content and its organization should reflect variety in the ways of knowing.
Student Model:	All students are products of a patriarchal society. Rules for behavior (including cognitive behavior) are gender-related and relationships between knowledge and behavior are knowledge-variant. Students vary in

	their acceptance or rejection of the values inherent in the Knowledge Domain.
Pedagogical Knowledge:	Each teaching strategy embodies elements of an educational philosophy; selection of strategies also reflects a philosophy of learning and of the teacher role. These philosophies must be articulated and allow querying.
Interface:	Natural language, itself, has masculine connotations. These connotations often preclude the translation of machine information in such a way as to communicate neither more nor less than the meaning of the machine language. Such translation should, however, be the goal.

The issues raised in this summary are many and they are related to all components of ICAI; the depth of these issues is illustrated by a single example. Sherry Turkle's (1984) analysis of adolescents working with Logo leads her to discuss the concepts of "hard mastery," a kind of technical mastery of Logo which is associated with the masculine, and "soft mastery," a more intentional mastery of the language. At the same time, Wenger (1987, p. 149, p. 425) observes that Logo provides a good paradigm for some aspects of ICAI. Bringing this work together implies that criterion referenced evaluation within a Logo Knowledge Domain should not be based solely upon technical proficiency with the language, but must also reflect the individualistic and creative work done by those in "soft mastery" of Logo. These same considerations have implications for the Student Model, and for the design of ICAI well beyond the Logo environment.

Conclusion

This paper provides a framework for comparing, contrasting, and in some cases, combining problems in instructional design with issues in the education of girls and women. The framework serves to structure several issues for further analysis. It is important to note that some issues of importance both to the design of computer-based instruction and to the instruction of girls and women fall outside this framework. For example, there is mounting evidence (Collis, 1987; Hawkins, 1987) that girls transfer mathematics anxiety to computer anxiety. One implication of this finding might be that ICAI is less appropriate for those girls than it is for boys; an alternate implication, and one that is more difficult to pursue, is that ICAI must become more responsive to the needs of girls and women than traditional mathematics instruction has been. The analysis above points out how complex a task this would be.

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Title:

SYMPOSIUM: Technological Equity: Issues in Ethics & Theory

Paper #3 Visual-Spatial Learning: Issues in Equity

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Visual-Spatial Learning: Issues in Equity

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Equity, that which is judged to be just or fair, is presumed to be a good thing. Equality, having the quality of of being equal, also is presumed to have a universal goodness inherent in its definition. However, when examined from a variety of perspectives, the terms equity and equality define related but different constructs whose pursuit can present some ethical and educational considerations. If we are concerned about women having skills equal to those of men, are we then not valuing those skills that are different from men? And if, for instance, there is some evidence that there is a lack of equal ability, then individuals who manifest less of whatever is being measured are quickly labeled as having a deficit (as opposed to those who have more being labeled as having a surplus). Equity, on the other hand, fosters fairness in opportunity. In our system of education, anyone has the right to develop aptitudes and abilities to their fullest potential. It is only just.

This paper discusses one such aptitude, visual-spatial learning, and some of the equity issues which are linked with it. It then outlines a program of research which might resolve some of the issues and exacerbate others. It sketches some of the ethical implications of the positions in the issues, and suggests dimensions which should be considered in research in order to ensure that the complex array of equity issues can be addressed.

Equity Issues

Fewer women than men enter professions which are built on mathematics and the physical sciences. There are many hypotheses for this phenomenon. A report by Lantz, Carlberg, and Eaton (1982) cites three major areas of differences between women choosing science and engineering and other women: interest, ability, and educational experiences. Women choosing careers in science and engineering are more interested in things than people and had more interest in mathematics and science. These women also tend to score higher on measures of ability, including verbal and mathematical aptitude, spatial visualization, science achievement, and grade point average. Educational experiences, as pointed out by the authors, are probably a result of the combination of the first two factors. Women scientists and engineers have more formal education in the sciences through increased choice of math and science courses, and they also have more informal experiences with math and science because of participation in science clubs and hobbies.

Spatial visualization and orientation have shown to have strong predictive validity for estimating success of individuals in the fields of engineering, science, drafting, and designing (McGee, 1979). It is no surprise, therefore, that fewer women are in these fields since they also tend to score lower than men on visual spatial aptitude measures.

How does this happen? Sex related differences don't become reliable until puberty, and then the difference become obvious. McGee (1979) discusses four possible sources of variance in spatial test scores: environmental, genetic, hormonal, and neurological influences. Some posit that women are socially encouraged to be more nurturing and dependent upon human interaction. And whatever the reason, many girls and women perceive mathematics and science to be the domains of males. A third explanation might be that schools and teachers subtly or blatantly advise girls and young women away from scientific, mathematical or technical studies. Genetic influences are yet to be proven, although there is some evidence that spatial abilities are probably as, or more, heritable as verbal ability. Hormonal influences such as an estrogen-androgen balance are also considered as a factor, but like the question of genetic influences, this factor needs much more empirical evidence. On the other hand, neurological influences do appear to be strong. These influences center upon hemispheric specialization, and two issues continually arise in studies: (a) the right hemisphere specializes in spatial processing and (b) males have more hemisphere specialization than females.

Educators have no control over genetic and hormonal influences; and given the opportunity to structure learning experiences for hemispheric activity, perhaps educators have a little influence on neurological development. Our major arena of influence is the educational environment-social, curricular, instructional, and affective influences of everyday school life. Another plausible reason for lessened spatial skill development in females is that women have been educated to use a type of thinking which is not the most productive in learning these subjects.

Most education is based on language-based learning. In language-based learning, ideas are expressed as a linear sequence of related propositions (just as the ideas presented in this paper are formulated). Girls in the primary and intermediate grades excel in this form of learning and thus demonstrate superiority on most instructional tasks presented in the first half of elementary and secondary schooling. There is a great deal of conjecture as to whether this superior performance results from a natural developmental capability or whether it results from the social and cultural differences in experiences which young girls have. At the very least, superiority in language-based learning probably influences girls to rely on their success and to avoid or ignore experiences which require other types of cognition.

Visual-spatial learning is multidimensional and simultaneous. Such learning cannot be expressed adequately in language. It is involved in problem solving of all types, but is especially important in scientific problem solving in which a complex array of variables interact with each other. Visual-spatial thinking may involve multidimensional visual arrays (when these are restricted to three dimensions one is dealing with pictures) or may involve multidimensional arrays or networks of data. People who learn and think using visual-spatial processes sometimes do not communicate these ideas in traditional ways making assessment problematic.

Gagnon (1985) and others (Frostig, 1972; Salomon, 1979) have found that it is possible in a relatively short time to train women in visual-spatial thinking to a level of parity with men. In fact, Gagnon found that men who experienced the same treatment did not make significant gains. This study, conducted on college students (as are so many of our studies), suggests that remediation of the cognitive skill of visual-spatial learning is relatively simple. It does not address the issue that by the time a woman had entered college, there have been all sorts of learning opportunities lost because upper elementary and high school females do not manifest a high level of performance in visual-spatial thinking.

Program of Research

Boys and girls have been measured to have parity in visual-spatial skills until they reach early adolescence although variations in performance alternatively favoring girls and boys make the picture rather complex. It is at the time of puberty, however, that visual-spatial performance of boys begins to be measured consistently higher than that of girls. Since there is no evidence that some earlier experience of the boys might contribute to the results measured much later, it seems reasonable to study whether some intervention in the fourth, fifth or sixth grades would maintain parity for the females and whether such parity was a positive influence on their learning mathematical and scientific concepts or their attitudes regarding these subjects. In addition, longitudinal studies would be required to ascertain whether pre-pubertal intervention will be sufficient or whether continuing intervention will be required throughout middle and high school.

Should the visual-spatial experiences be prepared as integral to the mathematics and science curricula or should they be developed as specially focused exercises just for the females. Research needs to be conducted to find out whether integrated curricular experiences can be developed which are perceived by teachers to be "covering" the expected curriculum at the same time that they are encouraging development of visual-spatial thinking. Can these experiences be motivating to females? Will the experiences have more powerful effects on the males (the rich get richer problem) or will such experiences slow the intellectual development for them?

Will teachers, who being mostly female do not understand visual-spatial thinking well themselves, be able to guide the learning of visual-spatial thinking by being sensitive to the subtile cues of translation of visual tasks into propositional tasks (an inefficient process often used by girls when confronted with a spatial task). How can teachers best be encouraged to develop visual-spatial thinking themselves. Can they experience powerful effects of their own visual-spatial thinking in their management of complex classroom environments? What sort of support system will be necessary to encourage commitment to visual-spatial matters after the novelty wears off?

How can social and cultural factors in the differential rearing of boys and girls interact with the cognitive and manipulative experiences in visual-spatial thinking to enhance the abilities of females in scientific and technical study. Can curricula in mathematics and science be developed which construct meaning in ways more in harmony with feminist culture? Can examples and problems be developed which will both be interesting and motivating to females and be stimulating of visual-spatial thinking?

Ethical Analysis

There would seem to be little doubt that a person should be able to function as well as her or his biology allows. Yet social, cultural and economic factors have served to limit people not only in accessing the means for the development of capability but also have focused individuals or groups on particular goals and aspirations. Contemporary society has increasingly voiced the goal of removing barriers to individual development. In addition, the increasing dependence of all on the products of technology has increased the importance of scientists, engineers, technicians, technical writers, and technical managers for the maintenance of convenience, comfort and (we hope) quality in life.

Women comprise slightly more than half of the population. Yet women represent a small minority in scientific, technological and management fields. Some might claim that women have other very significant roles in society. Yet there is widespread evidence that these "other" roles for women are neither valued by being powerful nor by being well-paid. It is surely too simplistic to claim that women are so underrepresented in science and technology because they perform less well in visual-spatial thinking, but if visual-spatial thinking is a factor, isn't it appropriate that educators and educational researchers should work to provide experiences for female learners to eliminate it?

Dugger (1986) feels that equity is a matter of balancing a variety of possibilities for the individual regardless of the gender of the individual or the traditional gender association of that trait. Under the discipline of this position, while girls were being encouraged to learn and use visual-spatial skills, boys would be learning nurturance or some other helpful, positive "female" trait. Addressing the notion of balance in curriculum and instructional design would be a complex task which would require the designer/developer to be concerned about a much wider range of variables than have been considered traditionally.

A third approach to curriculum and instructional design might be to attempt to develop gender neutral lessons for all people. Such an effort is probably doomed for many reasons including "traditional" expectations for schooling, the artificiality of pretending that gender does not apply, and the boring nature of most anything that is homogenized.

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Title:

SYMPOSIUM: Technological Equity:
Issues in Ethics & Theory

Paper #4 Educational Technology:
A Moral Issue

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Educational Technology, A Moral Issue

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The roots of rationalism in educational technology have been found in Greek philosophy, in the development of science, and in general technology (Saettler, 1968; Nichols, 1987). Today, we find rationalism in our belief, for instance, in the "Development of rationally sound instructional procedures" (Gagne`, 1987, p. 5). What follows contrasts the rationalism of educational technology with a version of Existential philosophy in order to see what dangers, moral implications, and alternatives might emerge.

The Dangers

The dangers of the rationalism of educational technology can be seen in at least three areas (Nichols, 1987). Physically, production of the hardware we buy, for instance, uses up the earth's resources, creates toxic by-products, and threatens the earth and human life. Socially, educational technology is threatening because it encourages poverty and social dislocation. Psychologically, our technology encourages disintegration of the self.

By "psychologically," I mean the self beyond the merely rational. Existential philosophy has come close to describing the self I mean, especially in that it has been the question of "a truth for man that is more than a truth of the intellect" (Barrett, 1958, p. 249). In *Death of the Soul*, Barrett (1986) characterizes the self as a passionate, persistent, *fully* conscious, moral identity and not simply, as described by some forms of rationalism, "some inert mental stuff or amalgam of perceptions" (p. 123). Of the dangers of such rationalism, he says, "The specialization of the modern mind is in the interests of efficiency: but this pursuit of efficiency can lead to compartmentalization of mind and the consequent fragmentation of the human person" (p. 111).

In the foregoing sense, technological equity is a question of equality, or wholeness, of the self rather than a question of equal access.

It's Dangerous, But Is It Wrong?

To propose that the rationalism of educational technology is dangerous is one thing, but to say it is wrong is something else. I want to contend, however, that a predominant rationalism is wrong in its danger and that there exists a moral principle against which we might make judgments about our educational technology.

A version of Existentialism may help to identify that principle. Most Existentialists believe that human being is the whole of individual existence, including the irrational as well as the rational. Barrett (1978) would call this the whole of consciousness and says, "Consciousness as the performer of intentional [rational] acts is thus intelligible only on the basis of our being in the world. It would be without roots or sense otherwise" (p. 145). The attempt to understand the whole of existence is a helpful rebuke to the danger of self disintegration. In all its dealings with death and nothingness, Existentialism also can help us to accept that discrete aspects of existence are not perfect; technological manifestations of our rationality have the power to destroy existence. Further, we must let existence reveal itself (Heidegger, 1977) in order to make progress toward an authentic self. A prevalent, controlling rationalism will only bring greater danger.

However, much Existentialism has had problems. (See Barrett, 1958.) It has focused on the individual and, so, is not anchored in the concrete existence of community, earth, or faith. Facing the great nothingness without community or faith may have caused the psychotic disintegration that overcame Nietzche. Also, it hasn't been able to reconcile the rational with the irrational. Sartre, for instance, turns out to be a Cartesian rationalist who avoids truth beyond the intellect by developing his "will to action," a controlling behavior. Perhaps most seriously, an Existentialist statement of morality has been difficult to conceive (A notable exception is Barrett, 1986.) and/or has not been widely disseminated or accepted. For instance, Heidegger never wrote an ethics, when to reach the ethical would require a leap into "another region of existence" (Barrett, 1978, p. 252) beyond the rational.

In contrast, I don't see existence as a primarily individual experience. It's communal in that humans and non-human entities share space and affect one another. Further, humans share existence that is both innate and learned. For instance, sharing is found in that as babies we all try to eat to survive (innate), and as parents most of us oblige babies' attempts to survive (learned).

Reconciling the rational with the irrational is more difficult. How, for example, do I express my fully conscious, tacit, intuitive feelings or knowledge in a predominantly technical world--in writing, for instance? Once we have a predominant rational consciousness, how do we get beyond it?

This is a profoundly difficult problem for which I will only suggest here that one path of reconciliation is by way of seeing educational technology as a moral question, and by this path we might begin to move beyond a difficulty of most Existentialism--stating and sustaining an ethical position.

The position outlined above offers an explanation of existence, but in order to begin judging our technology against it, we must go a step farther and say what is good about about this existence. Most Existentialists would say that existence or being just *is*. No judgments are levied. However, I propose the quite simple principle that Existence Is Good. That is, the whole of existence is moral, including the rational and irrational, the life and death, the human and non-human, the individual and the communal, the controlling and the letting go.

Now the phrase "the whole of existence" and the pairs of terms that characterize it are meant to signify a balance. or to repeat an earlier phrase, a "peaceful coexistence." And as long as these aspects of existence are allowed to be in balance with one another, existence is good, there is a moral condition. Conversely, let any of the discrete aspects predominate and there is immorality.

Some of our educational technology is in opposition to the balance of existence as I've characterized it. Through educational technology we impose and seek a predominantly rational view of learning and instruction. We strive for perfection, while our technology is only a discrete part of existence and cannot be perfect. We seek controlling rather than passive letting go. On at least these counts, then, our technology encourages an imbalance in existence. To this degree, our educational technology is not good.

In sum, in that they threaten us physically and socially, and so stop or impede existence, some forms of educational technology are, at best, morally suspect. To the extent that they seek a fully rational existence rather than a full existence, they may be morally indefensible.

Recommendations

Among the many suggestions that could be made if these conclusions have merit, I will make just two.

First, educational technology ought to be examined as a moral issue. Second, a statement of ethics, perhaps reflecting the position I have taken here, probably is needed. Producing such a statement runs the risk of reducing morals and ethics to a mere technicality. However, if it can be used more as guidance than as law, such a statement might be worthwhile. In that spirit, here are some possible guidelines for educational technology.

1. Seek to understand the full implications--negative, positive and otherwise--of educational technology.

2. Seek less to control learning than to allow it. This applies especially to instructional design, where students should have a say in this decision-making process.

3. Seek learning in all its aspects. We should look for and allow the mental, physical, and, shall we say, spiritual aspects of humans.

Conclusion

To conclude that educational technology may be morally indefensible is not to say that it is totally immoral, for that would be to claim that humans are always immoral. We have not completely lost our self, though the likes of human chemical and genetic engineering may lead us to full control and, perhaps, to the "death of the soul."

Educational technology is a moral issue, and I see evidence that others view it that way and are attempting to act accordingly. There are, for instance, symposia about the ethical nature of educational technology. And I believe these efforts come about through conscience and because existence *is* good. As a kind of evidence, I would ask if my claim that a predominantly rational-technical existence is dangerous has piqued your conscience.

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Title:

SYMPOSIUM: Technological Equity: Issues in Ethics & Theory

Paper #5 Instructional Technology and Proliferating World Views

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Instructional Technology and Proliferating Worldviews

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This paper briefly explores four concepts that are beginning to receive sustained discussion by groups in a number of places, including the instructional design and technology program at our institution. These four notions are: the value status of technology, the proliferation of worldviews, equity in education, and the relationship of ethical issues to practice. These four notions are interrelated and collectively raise questions, we will suggest, that speak to the future uses of the products of instructional technology in public education. At the end of the paper, we will attempt to raise a few of those questions.

No claim is made here that these four points are somehow definitive in capturing all the forces that impinge upon an evolving instructional technology. They simply seem useful to us in discussing issues that we think important to the future of this field.

It has been commonly understood that instructional technology is a value-neutral method of conveying instructional information. We will want to challenge that assumption by showing throughout this paper how instructional technology is value intensive in its support of a particular worldview, what we will call the scientific worldview.

When we use the term instructional technology in this paper we will have in mind the definition of that term as provided by Heinich in his 1984 *ECTJ* paper, "The Proper Study of Instructional Technology." Heinich is concerned with studying instructional technology in a way that make clear its technological origins. He offers definitions of general technology then explores how these definitions might help guide the development of instructional technology. While drawing on the definitions of general technology offered by John Kenneth Galbraith and Daniel Bell, Heinich moves beyond these to provide a definition of general technology that he finds isomorphic with his vision of instructional technology. Heinich's definition emphasizes the elements of replicability, reliability, communication and control among others (Heinich, 1984).

We are using Heinich's definition because we agree that a study of the larger notion of technology adds clarity to our understanding of instructional technology. His definition also serves to bring into sharp relief the counter issues we seek to raise in this paper.

Within the scientific worldview the assumption seems to be that systematic processes, scientific methods and scientific knowledge were not arrived at through political, economic and cultural decisions. Even if they were, the discussion is now over. Today, we have a reliable, authoritative and stable store of knowledge that can be passed on to the next generation. Earlier, we mentioned that these assumptions are beginning to attract sustained debate among a number of groups. These groups do not necessarily repudiate the practice and the tenets of science, general technology or instructional technology; rather, their objection appears to be that such entities do not represent their worldview and attendant knowledge.

Science, technology and instructional technology, as traditionally conceived, have influenced the way we view many ethical issues. One such ethical issue, important in the 1980s, has been the national debate carried on in the various educational reform documents over the subject of educational equity vs. educational excellence. Equity in education may be understood as extending the available educational resources to all people in the name of "justice, fairness or even mercy" (Smith and Traver, 1984). Instructional technology seems to be a good choice to distribute educational resources because it uses replicable, well documented, reliable techniques to communicate information. For example, an instructional technology product that involves mathematics instruction for girls is a public document that can be inspected for potential biases and general appropriateness. This is seen as an advantage over a live teacher whose instruction may not be available for perusal. Also, special provisions can be made for handicapped students to assist them in gaining access to educational resources via instructional technology. On the other hand, instructional technology may be assumed to be equally effective while serving the opposing position of excellence in education. Excellence, in contrast to equity, seeks a higher degree of human perfection and emphasizes higher **individual** achievement as the goal of reform in American education. The excellence movement "assumes that the only way to produce a good person or a good society is to have high expectations and to demand that these expectations be met through independent, individual effort" (Smith and Traver, 1984).

Equity seems to emphasize maximum access to educational resources for everyone while excellence seems to emphasize increased access to educational resources for those who excel. Here we have an example of how instructional technology becomes perceived as a value-neutral vehicle for the delivery of all knowledge. Within the scientific worldview, equity and excellence seem to be major opposing positions which can be served impartially via instructional technology when, in our view, these issues are primarily disagreements about how to distribute agreed upon, static information. That is, equity and excellence are part of a worldview that includes the notion that the established scientific knowledge base can be subdivided and redirected toward a pre-selected audience. This worldview does not assume a challengeable, fluid knowledge that requires constant review by different social groups with varying views as to what knowledge is pertinent to their world.

We want to provide here a brief sketch of one of the many ways the scientific worldview is being undermined today. It will hardly come as a surprise to people in this room when we note that something major has happened to the underpinnings of the human sciences during the past decade. Scientifically generated knowledge, once assumed to be unequivocal and atemporal, but open to accretionary growth like the Great Barrier Reef, has come under increasing attack. The presumed epistemologically privileged position of knowledge that results from rigorous application of the scientific method has been deeply--some would say, mortally--challenged. Clifford Geertz (1983) dramatically sums up the situation by saying, ". . . agreement on the foundations of scholarly authority . . . has disappeared" (p. 161). Extending this notion to professional practice, including theory and practice in our field, Donald Schon calls attention to "the crisis in confidence in professional knowledge" (Greene, p. 69).

This climate of crisis created by the challenge to a positive science worldview is allowing groups who hold alternative worldviews about the production and justification of knowledge, to take a greater forthrightness in the assertion of their positions. Groups such as the religious fundamentalists, blacks and people of color, and women's groups are, with growing confidence, demanding a fair hearing for their knowledge claims at the public policy level and in the curriculum and instructional programs of the public schools. We think these demands will grow and eventually translate into a significantly altered common education for public school students.

While these groups struggle to occupy a space left open by a retreating scientific worldview, it is not the knowledge claims, *per se*, of these groups that challenges science nor opens the space for the advancement of their claims. For this is the project of yet another group that will concern us here. The term "group" is perhaps granting too great a measure of coherence for what really amounts to a broad movement with disparate and even contradictory elements. Currently, there is no label that adequately characterizes the range of work under way. Quentin Skinner (1985) in *The Return of Grand Theory in the Human Sciences,* speaks of the "invading hordes" of "hermeneuticists, structuralists, post-empiricists, deconstructionists, and other(s) . . ." (p. 6). A subset of the invading hordes that intrigues us most goes under the rubric of "new pragmatism" or "social construction." We will use the terms interchangeably, although we admit to a growing preference for the term new pragmatism because it reminds us that elements of this position have been around since the beginning of the twentieth century. Richard Rorty, more than anyone else, has carefully articulated the arguments of the new pragmatism; therefore, our discussion, in this section, will take up his major ideas.

As a preface to a discussion of Rorty's new pragmatism, we think it prudent to provide a framework for understanding his ideas. One approach is to begin with the work of Thomas Kuhn. In his book, *The Structure of Scientific Revolutions* (1970) Kuhn lays out a theory of change in scientific knowledge that has been widely discussed. Change in science occurs in a revolutionary rather than an evolutionary way. Scientific knowledge does not gradually grow into ever larger structures. Rather, current structures or paradigms are replaced by newer paradigms that answer a broader set of questions or interests. This revolutionary process resolves extant anomalies between competing paradigms. This is the familiar part of Kuhn's thesis. Less familiar is Kuhn's conception of the nature of scientific knowledge that undergirds paradigmatic change. "Kuhn's understanding of scientific knowledge assumes that knowledge is, as he puts it on the last page of his book, 'Intrinsically the common property of a group or else nothing at all'" (Bruffee, 1986 p. 774). In Lauden's (1977) review of Kuhn's conclusions about scientific decision making and the corpus of knowledge flowing from such decisions, he notes that the process for Kuhn ". . . is basically a political and propagandistic affair, in which prestige, power, age and polemics decisively determine the outcome of the struggle between competing theories and theorists" (p. 4). Kenneth Bruffee writes this about Kuhn's position:

> For most of us, the most seriously challenging aspect of Kuhn's work is its social constructionist epistemological assumptions. A social constructionist position in any discipline assumes that entities we normally call reality, knowledge, thought, facts, texts, selves, and so on are constructs generated by communities of like-minded peers. Social construction understands reality, knowledge, thought, facts, texts, selves, and so on as community-generated and community-maintained linguistic entities--or, more broadly speaking, symbolic entities--that define or "constitute" the communities that generate them, much as the language of the *United States Constitution*, the *Declaration of Independence*,

> and the "Gettysburg Address" in part constitutes the political, the legal, and to some extent the cultural community of Americans (p. 774).

For Kuhn, scientific knowledge is a social construct. For Richard Rorty, all knowledge is a social construct. Rorty ". . . assumes that there is no such thing as a universal foundation, ground, framework, or structure of knowledge. There is only an agreement, a consensus arrived at for the time being by communities of knowledgeable peers. Concepts, ideas, theories, the world, reality, and facts are all language constructs generated by knowledge communities and used by them to maintain community coherence" (Bruffee, 1986, p. 177).

At least four ideas important to our discussion can be found above. Knowledge, for Rorty, is socially justified belief. Knowledge does not ground in universal principles. Truth is made, not discovered, and since truth is arrived at "only for the time being," truth is perishable. Therefore, truth is made in a community. It is not discovered, that is, it is not "out there" in the world waiting to be gradually uncovered through rigorous scientific investigation. According to Rorty, no single epistemology can lay claim to immutable truth that a second community is obliged to accept (Rorty, 1979).

For Rorty, truth and knowledge are no more or less than what someone wants them to be. Knowledge is words, metaphors offered by human wordmakers to describe how we might live (Rorty, 1986). Rorty invokes Nietzsche's concept that "Truth is a mobile army of metaphors."

The creation of worldviews or evolutionary change within a worldview results from the metaphors invented by the "strong poet." Strong poets created the two worldviews that have dominated Western culture over the past two millennia, namely the religious worldview and the scientific worldview. Rorty views religion and science as simply competing literatures. Literatures created by strong poets as to how we might obtain truth and use it as a standard to live by (Rorty, 1987). Religion and science are exclusionary literatures: only one way of knowing is to be sanctioned. Nonbelievers of the religious epistemology of divine revelation are considered "heretics;" claims of knowledge not validated by the epistemology of science are dismissed as "nonsense." Religion and science are prescriptive in terms of values. Similarly, technology is the embodiment of values that spring from the chosen literature. Technology, if not value saturated, does not exist at all.

Rorty's ideas, which for the sake of brevity we have admittedly simplified, we think will provide bases for the formation, in the years to come, of a large and powerful social group or coalition. Recruits for this group most likely will be made up of defectors from the scientific camp. It seems probable they will continue to translate their ideas into an educational agenda. At a minimum, the classroom will become a place where knowledge is created and recreated and where received knowledge, stripped of its epistemological authority, is closely criticized. To paraphrase an old line from Ted Rozack, received knowledge is not for the taking, but for the debunking.

Social change, even upheaval, would likely follow such a metamorphosis. As Ira Shor and Paulo Freire (1987) put it, "If teachers and students exercised the power to remake knowledge in the classroom, then they would be asserting their power to remake society. The structure of official knowledge is also the structure of social authority" (p. 10). Shor and Freire also foresee changes in the purpose and methods of instruction. Current instructional models, and we might include standard instructional technology here, are viewed as being compatible with a static and passive curriculum that promotes the current dominant authority in society and disempowers non-dominant groups.

"New pragmatism" does not endorse any epistemology, but in its attack on science it creates a void allowing for the empowerment of alternative "knowledge communities." In terms of public schooling, for instance, religious fundamentalists will expect their divinely revealed knowledge to be taken seriously. They will assert that their knowledge allows access to the fundamental nature of the meaning of life—the very purpose of human existence. They claim their knowledge reveals human destiny beyond physical death. Religious fundamentalist knowledge purports to show how to achieve contact with the Divine and to derive tangible benefits from such contacts. If religious fundamentalists are to perceive the public school curriculum to be representative of their knowledge community, then they will expect their knowledge to be woven into the fabric of school knowledge.

People of color are also asserting their own notions about how their knowledge should be represented. Beverly Gordon (1987) foresees the coalescence of a powerful new educational agenda: "In the twenty-first century, the struggle will be for the hearts and minds of people of color within Western societies and the global community. The critical battle will be for control over who educates people of color and over the nature of that education" (p. 442).

Women's groups are another instance of a knowledge community, historically ignored, that is now demanding recognition. The form this recognition will take, in the public school classroom, is still evolving. A major struggle of the past decade was to establish a place for women's work, both past and present, within the knowledge communities of the existing physical and human sciences and the humanities. This amounts to an adjustment in the literary canon of the existing disciplines. More recently there is talk of parallel disciplines, space that encourages women to create knowledge that is consonant with their deeply-felt values.

In the past women, and people of color have been typically characterized as gender and ethnic groups rather than knowledge communities with distinct worldviews. This reflects their traditional lack of power. This is likely to change. Women and people of color want students representing their constituencies to be able to make their own knowledge in schools instead of simply receiving and digesting knowledge supplied by the dominant worldview. They expect school to be a place where knowledge is produced rather than merely reproduced.

With these converging claims, the classroom is likely to become contested turf. Knowledge from conflicting worldviews will need to be honored. No longer will the knowledge of the scientific worldview be considered sufficient to animate classroom life.

We think that the classroom interplay of competing worldviews will be characterized in ethical terms. Major ethical issues seldom arise when a single monolithic world view holds sway over what counts as legitimate knowledge. Ethical issues within a single worldview tend to be relatively trivial since they involve matters of style or interpretations of the canon. Ethical questions are more likely to become central when competing worldviews clash over matters of substance and practice. When adherents of one worldview take positions based on perceived foundational principles that are idiosyncratic to their worldview, they are likely to view as unethical, demands for change originating from other worldviews.

Overarching agreement on a theory of ethical error seems unlikely since consensus itself might be viewed as unethical.

From this particular ethical perspective, educational equity might be viewed as something other than a simple exercise in altruism. Equity can be offered by members of the dominant worldview to members of other worldviews it deems inferior as a ploy to eliminate competing worldviews. Is equity a device for enforcing conformity? This question in a variety of forms is often raised today as a basic element in the revisionist critique of the Western liberal tradition.

Deconstructionists would raise similar questions. Their work seeks to demonstrate that our most cherished ideas, ideas such as equity, or justice, or even mercy, do not exist "out there" in the universe in some sort of ahistorical limbo waiting to be discovered and pressed into the service of humankind. Ideas, as such, have no existence apart from the individuals and groups who propose them. Michel Foucault constructs histories which describe how such ideas come to be proposed, how they are justified in a knowledge community and what use is made of them. In Foucault's dark formulations, the invention of such ideas--or knowledge--is inseparable from power. Knowledge and power are mutually reinforcing. Ideas are created to extend the power of a group already powerful enough to judge and punish a second group they label as deficient or deviant (Foucault, 1982, 1975).

In the public school classroom, the question is being raised as to whose knowledge is to count. Is it possible that at some future time knowledge from all knowledge communities or worldviews can be equally honored? How would the difficult ethical issues be negotiated? How can we hope to even hold open the conversation? As Richard Bernstein (1983) observes when writing about the work of Rorty: "We must appreciate the extent to which our sense of community is threatened . . . by the faulty epistemological doctrines that fill our heads. The **moral** task of the philosopher or cultural critic is to defend the openness of human conversation against all those temptations and real threats that seek closure" (p. 205).

If the common school classroom is to offer a space for the "great human conversation," where values, knowledge and action are guided by ethical negotiations and where knowledge groups are equally empowered, what might this mean for an evolving instructional technology? Instructional technology, as it has been thought of, has supported the delivery of an authoritative and relatively fixed knowledge base across time and space. Heinich holds that ". . . the basic premise of instructional technology is that all instructional contingencies can be managed through space and time . . ." (p. 68). The phrase "through space and time" means that the same static knowledge is delivered to the client group no matter where they reside, Malibu or Harlem, and, because that knowledge is locked into a software "time capsule," it can be opened when needed by the client group, tomorrow, six months or six years from now.

Replicability , alluded to earlier in Heinich's definition, means sameness: the same product once designed can be reproduced endlessly and used repeatedly. Reliability, as used in the definition, means the results or outcomes for the groups using the product are the same no matter where or when they use it. From an instructional design point of view, convergent and measurable responses pegged to carefully specified objectives make sense when attempting to transfer a pre-selected, invariant body of knowledge. Instructional designers use formative evaluation procedures to vouchsafe reliability; that is, to ensure the pre-selected knowledge is reproduced by the learner.

All this has served the field well. But how well will it serve the members of alternative knowledge communities who expect their young people to collectively engage in the creation of knowledge, or people who think knowledge, like bread, is best made at the local level? In the future, how will instructional technology respond to the requirements of fluid, multiple knowledge structures negotiated at the local level?

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Title:

SYMPOSIUM: Technological Equity: Issues in Ethics & Theory

Paper #6 The Ethics of Equity in Instructional Design

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THE ETHICS OF EQUITY IN INSTRUCTIONAL DESIGN

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One of the fundamental assumptions of instructional design is that the process facilitates fair, or equitable, instruction for all students. Needs assessment procedures are one of the ways used to insure instructional equity. Theoretically, instructional designers gather information from a variety of sources about a variety of issues, people, and resources, so that instruction can be optimized for each learner. Mastery learning is another means for insuring instructional equity. Prerequisite skills, knowledge, and attitudes are assessed and used to design instruction that capitalizes on individual capabilities. Alternative strategies are used to insure that each learner has the "best" learning environment. Criterion referenced evaluation is intended to provide fair assessment; remediation and enrichment activities are included to help an individual student reach her or his full potential. In fact, the very notion of "traditional" classroom instruction, that is, teaching to the average or middle group in a class, is distasteful to instructional designers who insist that each student is an individual and deserves special attention in relation to his or her capabilities. The ethical way to design and implement equitable instruction is to use instructional design procedures and strategies.

The use of technological means to increase individual potential is heralded by some as the crowning achievement of educational technology. Computers, high-tech video equipment, and robotic manipulators can be programmed to provide quality instruction for all minority, ethnic, and special groups by taking into account individual and group characteristics. An individual learner can proceed at his or her own rate, through sequences of instruction that are specifically suited to individual needs, with "correct" amounts of feedback to increase motivation, decrease anxiety, and increase achievement. Designers apparently have a world of possibilities at their fingertips. Yet, here is a symposium that questions some of the fundamental assumptions of the field. Perhaps, the authors suggest, educational technology does not provide or promote equitable instruction for all. Some of the authors suggest that we might be able to promote equity if we approached design differently; that is, if we asked different questions during a needs assessment, included different cognitive and affective knowledge and skills in our instruction or used different strategies. Other authors, however, take a more radical view and question whether or not educational technology and equity are mutually exclusive. Like the old George Carlin joke about military intelligence being a contradiction in terms, these authors wonder if educational technology and equity are an oxymoron.

There are no doubt numbers of arguments that can be made to refute or to support the educational technology and equity question. However, since the theoretical and philosophical bases of ID support equity in instruction, the purpose of this paper is to present three issues related to designing equitable instruction. The overriding question to be addressed is: How much of the instructional process should instructional designers control by pre-planning and managing instruction so that it is equitable or unbiased. Since this is quite complex, three related issues will be discussed that may help us come to grips with our responsibilities as educators regarding the design of equitable instruction.

Toward More Equitable Instructional Design

The issues raised in this paper are value questions or philosophical issues that have no inherent correctness or incorrectness to them. They are intended to promote discussion. The first issue addresses who is responsible for student learning, the designer who plans the instruction, or the student? The second issue addresses whether or not we can now or ever will be able to manage the contingencies of instruction so that we can insure student learning. The third issue focuses on student self-development and the requirement that students should assume some responsibility for their own learning. I have omitted specific issues related to knowledge bases and content that should be included in instructional objectives since Taylor and Swartz (1988) have already addressed these issues.

The Issue of Responsibility

I remember the first university course I taught using instructional design procedures. The course was an ID course and I was thoroughly prepared (or so I thought). I remember my devastation after the midterm when about one-quarter of the class did much more poorly than I anticipated. What had I done wrong? What did I forget in designing this class? Were the objectives too hard? Did I miss some prerequisites? Were the materials appropriate for the objectives? Were the examples representative? Did I fail to motivate the students? Using the systems approach that I had been taught, I tried to figure out what I had done wrong. I did not at the time give serious attention to the fact that perhaps at least some of the students who had done poorly were to blame for their own poor performance. Perhaps I had designed good or even very good instruction, and perhaps I had even delivered it well. Perhaps it was the students who had not taken responsibility for their own learning.

The first issue I would like to raise regarding equity revolves around the issue of who is primarily responsible for student learning? Instructional design theory highlights managing the contingencies of instruction, that is, pre-planning and organizing the design and delivery of instruction. While the learners' role can be active (Romiszowski, 1981), it is by and large the instructional designer or teacher who plans and manages the instruction.

Who Should be Responsible? I should have been prepared for the problem I faced with that first class because a professor of mine who was a strong advocate of instructional design once remarked that we (professors, students, and the educational system in general) were going to pay a price for assuming so much responsibility for student learning. He hypothesized that as designers and teachers took responsibility for insuring student success by assessing learner needs, setting objectives, determining optimal instructional strategies, using the latest and "best" delivery systems, construction and using fair evaluation devices, and "recycling" students who fail to reach mastery, that we left little responsibility for the learner. He summed up his thoughts by saying that student failures became our failures and that our failure was the inability to control the variables necessary to design "perfect" instruction. At what point, he asked, do we say that the learner didn't learn because of something he or she did or did not do, rather than because of something we did not do?

While the professor's comments are in some ways extreme, what he said also has some truth. Instructional design does put instructional control and decision-making in the hands of the designer or teacher. If we believe that we can control the variables and design adequate instruction, are we also assuming that by our efforts we should also be able to insure student success? I believe so. Yet research suggests that quality of instruction accounts for very little (perhaps 5%) of achievement variance (Martin & Briggs, 1986). Martin and Briggs (1986) state ". . ., and by any definition of quality of instruction *presently within our state of the art*, we estimate, with chagrin, that quality of instruction must be ranked relatively low as we have it here, among the more powerful influences upon learning" (p. 31). They suggest that the more powerful influences on student achievement are home environment, intelligence, motivation, and self-esteem to name only a few.

Instructional designers persist. We want to activate the internal processes of the learner, insure their attention, and motivate them by designing exciting instruction. Having done the above, if a student is not successful we generally conclude that the instruction was flawed and that we can correct it. Rarely do we say (at least publicly) that the student didn't try hard enough, or didn't spend enough time, or didn't care enough.

I have intentionally overstated this issue of responsibility because I believe it is one of the key ethical issues that instructional designers have to contend with when dealing with issues of equity. Naturally, instructional designers and teachers must assume some responsibility for student success and failure. There are things we know which promote student learning, such as time on task, and our designs can provide for adequate practice opportunities with appropriate learning materials. However, there is no guarantee that each learner will succeed using these methods and materials *without internal motivation and active involvement*. There are some things that we neither can be responsible for nor should we be responsible for. Where that balance lies between our responsibility and student responsibility is one of the important ethical decisions we will have to face as we address the issue of equity.

The Issue of Managing the Contingencies of Instruction

There is certainly nothing wrong with attempting to design instruction that is motivating and that meets the needs of each learner, but the task we set for ourselves in trying to control every aspect of instruction, making it responsive to each and every students is impossible. It is not impossible because we do not try hard enough, or because the desire is not there, it is impossible because there are too many variables with which to contend. ATI research demonstrated that years ago. After years of research and substantial reviews of the findings Cronbach and Snow (1977) concluded that "no Aptitude X Treatment Interactions are so well confirmed that they can be used directly as guides to instruction" (p. 492). In addition to inconclusive results were a number of other problems with ATI research: inconsistent results, results that were not replicable, generalizations that were not stable across populations groups, and even generalizations that were not stable from one decade to the next (Tobias, 1987).

There are some parallels between the ATI research and the issue of controlling the variables in instructional design. Reiguluth (1983) has spearheaded a "movement" to develop a prescriptive theory of instructional design. It has much the same motivation as the ATI research, that is, to determine the optimal methods for instruction under certain conditions (learners and environment) for prespecified, desired outcomes. Given such a prescriptive theory, instructional designers and practitioners could develop instruction systematically with some degree of certainty that prescribed methods would produce desired outcomes for particular groups of learners under certain conditions. The search, then, is for a science of instructional design.

What Reiguluth and other researchers (Gropper, 1983; Landa, 1983; Snelbecker, 1983) are attempting is noble, however, it may be futile. It may be that, like the ATI research preceding it, that there is no systematic way to develop a comprehensive theory of instructional design. This need not be looked at as a failure. The problem may be a practical one, that is, there are too many variables to account for and control and that the amounts of variance that any given variable can account for fluctuates from situation to situation, over time, with different groups.

Nichols (1988) suggests, however, that the issue of managing the contingencies of instruction may be a moral one. Using an existential point of view, he questions the "predominantly rational view of learning and instruction" proposed by educational technologists. He characterizes extreme rationalism and our quest for controlling instruction and learners as morally indefensible.

If it is either a practical impossibility to design instruction with the precision we desire or if it is morally indefensible, what is the ethical approach to designing instruction, taking into account the individual learner, special interest groups, and ethnic and minority groups, specifically instruction that is more responsive to females (Belland & Baker, 1988; Damarin, 1988) and to disabled learners (Howell, 1988)? How much can we promise? Which group(s) should receive the lion's share of our time and resources?

While there are numbers of related ethical issues regarding managing and controlling instruction, the one I would like to highlight is: Are we promising too much to practitioners and learners? Based on excellent research done previously, i.e., the ATI studies, we know that we cannot now and may never be able to be as precise in our design as some would like. The fact that this is true should not deter us as a field from continuing to discover generalizations about optimal methods for specific groups of learners. However, it is unethical to promote the idea that we presently have a science of instructional design that "works" or that we will have one in the near future.

There is, however, much valuable information that we can impart to practitioners, e.g., the benefits of systems thinking and systems design, the benefits of objectives and criterion referenced evaluation, and the benefits of computers and interactive video discs. But there are multiple points of view about the theoretical bases and practical ideas we support and promote. Part of our job as educators is to stimulate discussion rather than to say we have grounded answers and findings when in fact we do not. Practitioners are capable of making their own decisions. If our ideas and theories are sound, they will "sell" themselves.

The Issue of Learner Self-development

One implicit purpose of education is to increase learners' independence and self-reliance. We want students who can think for themselves, direct and be responsible for their own learning, and who are self-motivated. Even though some of the papers presented here suggest that we as instructional designers need to be more responsive to the needs of a greater variety of learners in the design process, they also say that we need to promote and foster self-development. For example, Howell (1988) makes a plea for instructional designers to plan and implement instruction that assists disabled learners to become more self-sufficient and independent.

Belland and Baker (1988) and Damarin (1988) describe the need for increasing the individual freedom of women. Although, Belland and Baker focus on visual-spatial thinking as a factor in limiting female development, their interest appears to be in providing full opportunities for all learners whether male or female. They say, "In our system of education, anyone has the right to develop aptitudes and abilities to their full potential."

Damarin, describing ICAI and its potential benefits and effects on women, suggests that ICAI include indices such as difficulty, anxiety, and usefulness attached to the mathematical knowledge domain so that the female learner might have greater control over her own learning. Since research suggests that different cultural groups and perhaps males and females use alternate modes of information seeking and gathering, the implication is "that the organization of concepts in ICAI must be fluid rather than fixed, giving learners the opportunity to structure their own knowledge in a manner consistent with their own linguistic and cognitive structures."

Nichols (1988) concurs. He suggests that students should have more say in the instructional design process. He goes on to suggest that educational technology may fail to develop the whole essence of individuals, that we in fact compartmentalize individuals. Rather, "We should look for and allow the mental, physical, and, shall we say, spiritual aspects of humans."

These authors are calling for a learning system and environment that fosters individual self-development. The goals are to (a) increase the personal independence of learners, and (b) allow opportunities for choice and decision-making in the instructional design process, while at the same time providing for (c) specialized educational interventions that reduce or eliminate bias toward ethnic, minority or special interest groups so that these learners can reach their full potential, and (d) provide access to tools and experiences that will increase the quality of life for all.

One of the external conditions of learning that promotes personal independence and self-development is to provide opportunities for self-directed behavior, for example, opportunities for learners to set their own goals, evaluate their own performance, and select and use learning activities and strategies suited to their learning styles and preferences (Martin & Briggs, 1986). In order to provide these opportunities instructional designers may have to relinquish some of the responsibility and control of the design process and develop instruction that is more flexible and that is not replicable since objectives, activities, strategies, and evaluation may vary to fit learner needs *from their perspective.*

The issues related to promoting self-development, by providing opportunities for choice, are fairly obvious. Questions arise such as:

1. How competent are students to determine what they should learn? Will they omit important content that is crucial for fully functioning in this world? Are designers more capable than students and parents in determining which pre-selected body of knowledge to transfer (Taylor & Swartz, 1988)?

2. How capable are special students, i.e., disabled learners, functional illiterates, to select appropriate objectives and learning methods that will increase their cognitive and affective development? If designers provide a range of options so that students can make choices, is that adequate?

3. How should we respond to gender issues? What if educational interventions have the opposite effect than intended, e.g., a more powerful effect on males (Belland & Baker, 1988)? How should we respond to researchers from the feminist perspective who state that knowledge is not value-free and may have masculine connotations? What if students are unaware or unconcerned about these issues?

4. Should instruction first be designed that teaches students how to manage their own learning as Derry (1984) and Sternberg (1983) have suggested. If yes, what aspects of curriculum should be omitted so that this instruction can be included? How much influence should instructional designers exert in preparing such instruction.

There are no easy answers to such questions. There is no way to know how much pedagogical knowledge to apply to any learning situation, nor is there any way to know how many options to give individual learners, or how often to do so. To even attempt to define such rational and logical procedures offends some. However, the issue can be approached as an ethical one. We have the responsibility as educators to promote student self-growth and development. We also have a responsibility to extend and expand the knowledge base in our field so that quality instruction can be designed that provides a chance for all learners to have a full and rewarding life. How we balance these two responsibilities is an ethical issue.

Summary and Conclusions

At the philosophic core of instructional design is the belief that each learner is an individual and that instruction can be designed that capitalizes on individual strengths. Therefore, we support and promote equity in instruction. What causes concern for some in our field is that the knowledge we select and the processes and strategies we use may actually deter us from our goal of designing equitable instruction. So, while we maintain the belief that we can and should design unbiased and impartial instruction for all learners, the research (and our practical experience) leads us to question the practicality of this assumption. In relation to this, three issues were raised.

The first concerns who is responsible for student success. Instructional designers have perhaps taken more responsibility for student success than they should. By trying to control and manage the contingencies of instruction so that each learner succeeds, we have taken responsibility for success away from learners. We need to think again about who is responsible for student learning, including what the learner should be responsible for and how to promote responsible behavior. Some of the research on social learning theory constructs such as self-efficacy (Bandura, 1977) and self-regulatory behavior (Bandura, 1978), and the research on attributions (Bar-Tal, 1978; Weiner, 1979) and learned helplessness (Abramson, Seligman, & Teasdale, 1978) may provide valuable insights on how to proceed with this.

The second issue deals with our ability to design instruction that delivers what it promises. Instruction is a science and an art. To suggest that we have developed a comprehensive theory of instructional design or that we can is misleading. To suggest that we can design instruction that will meet the needs of each learner and that will be unbiased toward any group is a fallacy. Some of what we know we can be fairly sure of; other aspects of our theories are educated guesses; still other aspects are mere shots in the dark. Although other researchers and practitioners are capable of interpreting research for themselves, we also need to provide honest and clear interpretations. We should not promise what we cannot deliver.

The last issue concerns learner self-development. In order for learners to become independent and self-directed, we need to provide them with opportunities to design aspects of their own learning. To do so means that as designers will have to accept the fact that learners can make some choices that are better for themselves than we can. We will have to give up some of the control we have previously had and turn it over to learners. Ethically, we are committed to providing the best learning experiences for all students. However, as we apply what we know about learning and instruction to the design process and take more control of that process, we run the risk of reducing opportunities for students to become decision makers and participants in the instructional process. Theoretically at least we may limit student self development by providing the "best" instruction we can.

The original question posed at the beginning of this paper was: How much of the instructional process should instructional designers control by pre-planning and managing instruction so that it is equitable? If we agree that students should be at least equally responsible for their own academic success as we are and that promoting self-development by providing learners with opportunities to make choices about their own learning is important, then we have to face the fact that we will have to give up some control of the learning process. This, coupled with the fact that we may not be able to plan completely unbiased and equitable instruction, means that we need to ask different questions. we may need to begin to search for answers to questions such as:

1. How do we promote a learning environment that helps learners become responsible for their own success?

2. At what point can we say with some assurance that certain methods, activities, and strategies will be successful? How much can we promise from our research?

3. How do we promote learner self-development and at the same time make the best use of our knowledge about designing and managing instruction?

It is doubtful that the answers to such questions will come from research. They will most likely come from individuals and groups of individuals who participate in symposia such as this, and also from our work with students, schools, and businesses. And of course the answers will come as we continue to critically review our goals as educators and the theory bases of our profession

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Title:

Cognitive Style Factors and Learning from Micro-Computer Based and Programmed Instructional Materials: A Preliminary Analysis

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Cognitive Style Factors and Learning from Micro-Computer Based and Programmed Instructional Materials:

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Rationale

Last year's AECT Convention produced a significant number of RTD Papers on the topic of micro-computer based instruction (MCBI). In addition, other related professional areas are experiencing similar interest in the design of high quality MCBI instruction, for academic learning as well as skill development in industrial and business training. For example, a recent special issue of Engineering Education Journal (1986) was dedicated to the design of MCBI for science and engineering curriculums. The 1987 American Society for Engineering Education Annual Conference had a significant number of research papers on the design and application of MCBI for improving instruction in science and engineering (1987). A recent article by Wise (1986) indicated a similar interest in MCBI applications for business training, finding MCBI to be effective for learning and also cost effective (also, Carney 1987). Additional interest with MCBI can be found at ASTD Annual Meetings, as well as other specialized education meetings, such as The National Science Teachers Association Conference (1987). However while a significant level of interest exists for MCBI instruction, and research and development with MCBI continues, few of these presentations and studies have considered cognitive style variables. Cognitive style variables can have a significant impact upon the perception and learning of academic information (Cross, 1976). Additionally, the micro-computer seems to be the only technology allowing for a true systematic examination of cognitive style by instructional design relationships (Gagne, 1983). While early attempts at such trait-by-treatment interactions research proved less than favorable (Hunt, 1973), such learning style issues can now be examined within the context of real academic instructional situations, to observe the perceptual and learning differences caused by cognitive styles.

The present study examines two cognitive style variables, in three separate experimental designs. This study is a preliminary study, to evaluate cognitive styles, and instructional and testing conditions. A later study is planned implementing these evaluated instructional and testing materials into MCBI conditions, and further examining cognitive style effects on perception and learning.

Cognitive Styles

While much has been written about cognitive styles, there seems to be a good bit of misconception about what cognitive styles actually are, and what effect specific cognitive styles have upon learning and perception. Surprisingly, educators are now in a position to examine these individual difference types, with the use of MCBI, but few new trait-by-treatment studies have been completed.

Cognitive style was originally defined as a perceptual characteristic caused by the interaction of genetic factors and environmental factors as the individual develops or simply stated, perceptual behavior is a function of the person and environment, [B, F(P,E)], (Lewin, 1935; Cronbach, 1967; Hunt, 1973). Cognitive style can then be operationally defined as the differences in perception individuals have of information in the environment, based upon their background. In other words, the same perceptual situation may be viewed differently by two individuals, contingent upon their cognitive styles. For example, a high dogmatic individual may perceive a political candidate much differently than a low dogmatic individual views the same political candidate. Similarly, the low dogmatic cognitive style will actually "see" different things, usually more information, in the same situation as experienced by the high dogmatic cognitive style. While the cognitive style issue has implications for personality research and perception (i.e. the vast number of studies done on Dogmatism), such perceptual factors will impact upon learning (Witkin, 1873):

> "Cognitive style is a potent variable in students' academic choices and vocational preferences; in students' academic development through their school career; in how students learn and teachers teach; and in how students and teachers interact in the classroom." (p.1.)

However, while a good deal is known about the topic of cognitive styles, little of this knowledge has been used by educators, for example (Cross, 1976):

> "Unfortunately, not one teacher or counselor in a hundred knows anything at all about cognitive styles despite the fact that research on cognitive styles has been going on for some twenty-five years in psychological laboratories."

As Kogan noted sometime ago (1971), this type of situation is caused by a total lack of articulation between psychological study of cognition and those conducting and reporting educational research, and those in the practice of education and teaching. This situation should be remedied by those researchers involved in applied educational research. A variety of cognitive styles have now been identified, and most of these researched to varying degrees. Currently about 12-18 different cognitive styles have been investigated. Here is a definition of 9 of these cognitive styles developed by Messick (1970):

> 1. Field independence versus field dependence - "an analytical, in contrast to a global, way of perceiving [which] entails a tendency to experience items as discrete from their backgrounds and reflects ability to overcome the influence of an embedding context."

2. Scanning - "a dimension of individual differences in the extensiveness and intensity of attention deployment, leading to individual variations in vividness of experience and the span of awareness."

3. Breadth of categorizing - "consistent preferences for broad inclusiveness, as opposed to narrow exclusiveness, in establishing the acceptable range for specified categories."

4. Conceptualizing styles - "individual differences in the tendency to categorize perceived similarities and differences among stimuli in terms of many differentiated concepts, which is a dimension called conceptual differentiation as well as consistencies in the utilization of particular conceptualizing approaches as bases for forming concepts-such as the routine use in concept formation of thematic or functional relations among stimuli as opposed to the analysis of descriptive attributes or the inference of class membership."

5. Cognitive complexity versus simplicity - "individual differences in the tendency to construct the world, and particularly the world of social behavior, in a multidimensional and discriminating way."

6. Reflectiveness versus impulsivity - "individual consistencies in the speed with which hypotheses are selected and information processed, with impulsive subjects tending to offer the first answer that occurs to them, even though it is frequently incorrect, and reflective subjects tending to ponder various possibilities before deciding."

7. Leveling versus sharpening - "reliable individual variations in assimilation in memory. Subjects at the leveling extreme tend to blur similar memories and to merge perceived objects or events with similar but not identical events recalled from previous experience. Sharpeners, at the other extreme, are less prone to confuse similar objects and, by contrast, may even judge the present to be less similar to the past than is actually the case."

8. Constricted versus flexible control - "individual differences in susceptibility to distraction and cognitive interferences in

susceptibility to distraction and cognitive interference."

9. Tolerance for incongruous or unrealistic experiences - "a dimension of differential willingness to accept perceptions at variance with conventional experience." (pp. 188-189)

The systematic evaluation of cognitive styles, and how to design effective learning conditions for each specific cognitive style, should be further examined. However, while early trait-by-treatment interaction research studies were worthwhile, the practical application in the classroom of cognitive style specific instructional conditions proved impossible. Fortunately, today the micro-computer has changed this situation by allowing for highly individualized instructional programs to address specific learning needs.

The cognitive styles examined in the present study are field-dependents-independents and reflectivity-impulsivity. A definition of both of these cognitive styles is provided in the above listing by Messick, however a few more points on these cognitive styles. Field-dependents-independents was originally researched by Witkin (1954). His original work lead to a large number of studies on fd-fi (Witkin, Oltman, 1973), with this research yielding results having significant implications for instruction and learning (Witkin and Moore, 1975). In terms of viewing an instructional display, the field-independent student will be able to abstract relevant information more easily, probably acquire information more quickly, and require fewer individual cues. On the other hand, the field-dependent individual will have more difficulty identifying relevant to-be-learned information from the visual instructional display, and will have more difficulty learning from complex visual displays. On the other hand, the field-dependent student may learn better with more visual cues and more reinforcement. So the basics of designing an instructional display should differ significantly contingent upon relative field-dependency or field-independency. Thus, knowledge of fd or fi can predict how to design instructional events, and MCBI instructional displays.

Early work on reflectivity and impulsivity was carried out by Kagan (1965; Kagan, Rossman, et.al., 1964). Recent research on this cognitive style has been carried out by Ernest Barratt. An extensive series of studies, now done by Barratt examines the reflectivity and impulstivity cognitive style (Barratt, and Pattan, 1983; Barratt, 1980; Barratt, 1972; Barratt, 1965). Similar to fd-fi, the reflectivity-impulsivity cognitive style has implications for how students deal with the instructional environment, and specific instructional displays. For example, the impulsive learner may be less likely to view an instructional display for the correct amount of time, or may not attend to visual detail. Therefore, external pacing strategies may be needed in the MCBI program, to deal with the impulsive cognitive style. Additionally the impulsive cognitive style may avoid feedback loops, or additional study when needed, so these considerations should be designed into the MCBI program. However, the reflective cognitive style may find such built in strategies debilitating, so a cognitive style specific instructional program may prove more effective.

Cognitive style variables are so pervasive in learners, and such powerful psychological systems, it would seem that cognitive styles should serve as a basic consideration for the design of MCBI instructional programs. Along with the optimal design of visual displays and pace considerations, cognitive style effects may help instructional developers design optimal MCBI programs for most learners.

Experimental Designs

The present research study involves three experimental designs, two investigating the cognitive style of field-dependents and field-independents and one evaluating the reflectivity and impulsivity variable.

The first fd,fi experimental design is represented by figure 1. The fd,fi variable was determined using the Thruston Embedded Figures Test. Two hundred experimental subjects were tested for fd,fi. The fd,fi scores were analyzed and split, so that the middle portion of the scores were eliminated leaving scores that were as close to being fd or fi as possible. This left 112 subjects to participate in the study. These 112 subjects were then split into fd and fi groups based upon their relative fd and fi scores.

The programmed instructional (PI) texts instructed subjects on the parts of the human heart and how the heart operated (Dwyer, 1987). Each PI text contained visual and verbal information in an instructional display, followed by an instructional question and feedback. Each PI text had exactly 37 instructional displays, and 37 instructional questions, for each display. The PI texts simulated a computer display in style, and served as a pilot set of instructional materials for later computer programming. There were two types of visuals evaluated, and two types of feedback evaluated in the PI texts. The first visual type was a simple line drawing of the heart. While this visual type was complete, with all correct information, finer detail was not in the visual. The second visual was a detailed line drawing, which included the same basic information as the simple line drawing, but with added detail. Both visual types were in black and white. An instructional display consisted of a visual of the heart, labels indicating heart parts or operations, arrows specifying parts or operations, and a brief verbal explanation under each visual.

The two types of feedback were verbal or visual. On the verbal feedback condition, after the subject responded to the instructional question, the PI text page was turned and the correct answer was then provided in verbal form. In the visual feedback condition, after the subject responded to the instructional question, the page was turned and a heart visual appeared with the correct answer in verbal form and an arrow identifying the process or part on the visual. The two visual types and two feedback types resulted in the following four PI Instructional conditions.

1) Simple line drawing plus verbal text, and visual feedback.

2) Detailed line drawing plus verbal text, and visual feedback.

3) Simple line drawing plus verbal text, and verbal feedback.

4) Detailed line drawing plus verbal text, and verbal feedback.

After working thru the PI texts at their own pace, subjects were given a recall test. There were two types of visual tests evaluated: 1) Free recall visual test. 2) Cued recall visual test. The free recall visual test required the subject to draw a picture of the human heart, with the parts indicated and labeled, and show the correct blood flow. The cued recall visual test required the subject to draw a picture of the heart with the parts indicated, this test had a listing of the parts provided in random order at the bottom of the page. As with free recall test, on the cued test blood flow had to be shown. Both test types had 20 possible points.

The second experimental design is represented in figure 4. The second experimental design involved the same subjects, the same PI texts, but different test types. This experimental design used verbal testing in place of the visual tests from the first experimental design. There were three types of verbal tests (each had 20 points):

1) List Learning: list the heart parts and operation names.

2) Simple concept learning: given a multiple choice question describing the attributes of a part or operation, identify the correct concept.

3) Complex concept learning: given a multiple choice question which describes the interacting operation of heart functions, identify the function, relationships, or interacting parts.

The third experimental design was not a true experimental design, as were one and two. This design was a pilot study to evaluate performance of the subject pool on the Barratt's reflectivity and impulsivity, cognitive style test. Using a subject pool from another experiment completed at Ohio State, 180 experimental subjects were given the Barratt test. The Barratt reflectivity-impulsivity test has three subscales to evaluate a subjects relative impulsivity or reflectivity

1) Non-planning
2) Motor response
3) Cognitive

The first scale deals with the ability to plan for future actions, the second deals with motor behavior of a physical nature. The cognitive scale deals with intellectual skill activities. The subject pool's reflectivity-impulsivity scores were normed for a future experiment on this cognitive style, and to determine which subscale to use for a future experiment with micro-computer based instruction. Norms on the Barratt test currently do not exist for college freshmen, our subject pool. Additionally, the scores may vary across the scales. In other words a subject may be high cognitive impulsive, and low motor impulsive. Therefore, it was necessary to determine which scale predicted relative impulsivity vs. reflectivity for this subject pool. This data on the Barratt's scales was collected as part of a separate experiment, and analyzed using a psuedo-experimental design to evaluate subscale mean differences.

The Barratt test norms will be used in a future study to evaluate the effects of reflectivity and impulsivity on learning from micro-computer based instructional programs.

Results and Discussion

The first experimental design resulting analysis of variance is summarized in Table-1. The Table-1 data yields a number of significant results. The instructional type variable was significant. A Tukey follow-up test, at .05 alpha, indicated that the PI instructional text, with a line drawing visual and visual feedback, produced a higher mean score overall on the visual tests (Table 2). The more detailed line drawing with verbal feedback produced a significantly lower score. The detailed line drawing plus visual feedback means, and line drawing plus verbal feedback scores did not differ.

The line drawing visual type appears to have an adequate amount of visual information for learning, and when paired with visual feedback, significantly improves learning. The added detail in the detailed line drawing did not significantly improve learning, however this added detail would significantly add to programming complexity for MCBI. Additionally, visual feedback is better overall, and is better than verbal feedback alone.

In general, the fi group outperformed the fd group, and cued recall was not as difficult as free recall (Table-2). These results are expected from past research on fd, fi and cued, free recall.

A significant interaction occurred between instruction and testing type, the means involved in this interaction appear in Table-2, with a graph of the interaction in Figure-2. The source of the interaction is the PI-text type of line drawing plus visual feedback. This instructional condition produced a highly significant improvement in learning performance on the cued recall visual test. As in the main effect mean differences, this line drawing instructional display condition, with visual feedback, was better for learning visual information than a detailed line drawing and verbal feedback. However, free recall of visual information remains a difficult task as indicated by the mean scores in Table-2.

A significant interaction occurred between fd, fi and test type (Table-2, Figure-3). The field-independent group did significantly better on the cued recall test than did the field-dependent group, but both cognitive styles had more difficulty with the free recall visual test.

Interestingly, a highly significant finding, is the lack of significance found in the second experimental design (Figure-4). The Table-3 analysis of variance results indicated that verbal testing alone failed to reveal performance differences, in performance with the cognitive style of field-dependents-independents. In other words, if the experimenters used only verbal tests, and not visual testing, our results would have been quite different, or insignificant. This lack of significance with verbal testing, using the same instruction and same subjects, points out a key issue with cognitive style research; testing conditions for intellectual performance must be sensitive to the cognitive style factors being examined. The cognitive style will always be at work, since it is an innate psychological factor, but if criterion tests are insensitive to the cognitive style examined, results will fail to reveal performance differences. A comparison of the Table-1 and Table-3 results makes this principle obvious, and yields the conclusion that visual testing should be a consideration for examining the field-dependent and field-independent cognitive style. In addition, it makes obvious the need for pilot testing instructional and testing materials for cognitive style sensitivity, when researching cognitive styles and instructional factors.

Well, what did we learn from this preliminary analysis for our next study on MCBI? First, our MCBI instructional programs will eliminate the detailed drawing, plus verbal feedback condition. This instructional condition will be replaced with a condition to examine visual cuing during instruction, and if this extra visual cuing will improve free recall test scores, and overall visual test scores for field-dependents. Secondly in our next MCBI study, with the original three PI-Instructional conditions adapted to MCBI, we plan to eliminate verbal testing. However, along with the free recall and cued recall visual tests, we will add a visual oriented test to evaluate concept understanding. In other words, this third test will evaluate conceptual ability with the heart content, but include a visual dimension during testing. Thirdly, in the follow-up study, from this pilot study, we will further evaluate fd and fi, but with the added effects of an MCBI method of instruction, a visual cue oriented instructional condition, and a visual concept test.

The psuedo-experimental design is summarized in Table-5, relevant reflectivity-impulsivity mean scores are presented in Table-6. While this analysis includes data from another study, the only relevant variable is the cognitive style mean scores, and in Table-5 the data listed as 3-Subscales. This relectivity and impulsivity data was collected as part of another study evaluating 8 instructional conditions. The analysis of variance design in Table-5 was only used to norm the 3 reflectivity-impulsivity subscales for future work.

The three subscale means proved to be statistically different for this group of 180 college freshmen. They tended to be more highly cognitively impulsive (18.71), than planning impulsive (14.92), and motor impulsive (16.93). Additionally, their overall mean scores on the three subscales tended to fluctuate a great deal from subject to subject. Therefore, it may be difficult to use all three subscales in one experimental design, but better to examine one subscale at a time. Since the cognitive subscale seems to relate more closely to academic work, our next cognitive style experiment dealing with reflectivity-impulsivity, will evaluate relative performance using the cognitive subscale.

Finally, these norms on the three subscales are valid for college freshmen, since our subject sample size was 180 in this case. However, since little is known about reflectivity-impulsivity for college students, more should be done on developing norms on the Barratt test on this cognitive style.

	LD, Vis.F.		DD, Vis.F.		LD, Ver.F.		DD, Ver.F.	
	Line Drawing, Visual Feed.		Detailed Drawing, Visual Feed.		Line Drawing, Verbal Feed.		Detailed Drawing, Verbal Feed.	
	fi	fd	fi	fd	fi	fd	fi	fd
Cued								
Free								

Figure 1: Visual testing, fdfi, Experimental Design

Source	Mean Sq.	Df	F-Ratio	P
Instruction (I)	34.68	3	2.77	.05
(fi) x (fd)	52.94	1	4.23	.04
(I) x (fd,fi)	17.72	3	1.42	.24
Test (T)	167.58	1	13.39	.001
(I) x (T)	35.79	3	2.86	.04
(T) x (fd,fi)	87.51	1	6.99	.01
(T) x (I) x (fd,fi)	5.29	3	.42	.74
Error	12.51	96	----	---

Table 1: ANOVR Summary Table Visual Testing

Instruction Means:

LD, Vis.F.	DD, Vis.F.	LD, Ver.F.	DD, Ver.F.
7.82	6.68	6.50	5.11

fi x fd Means:

fi	fd
7.21	5.82

Test Means:

free	cued
5.30	7.75

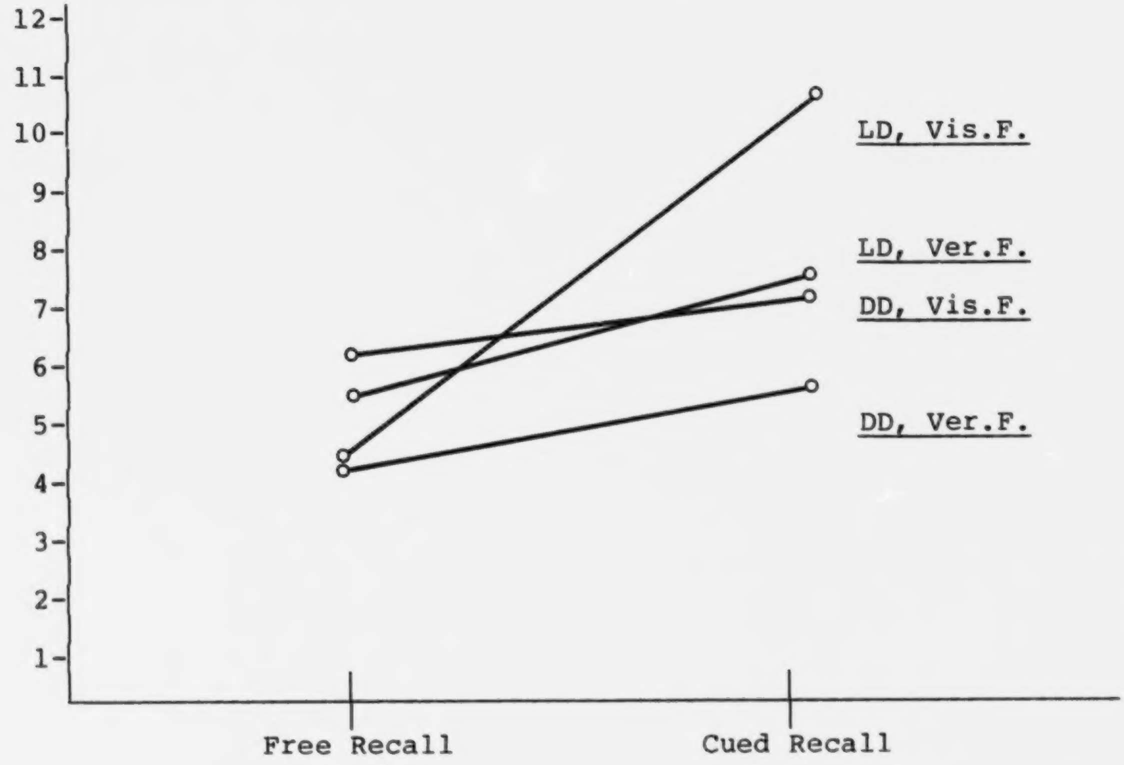
Instruction x Test Interaction Means:

(LD, Vis.F.)	(DD, Vis.F.)	(LD,Ver.F.)	(DD, Ver.F.)
Free, Cued	Free, Cued	Free, Cued	Free, Cued
4.73, 10.71	6.29, 7.07	5.64, 7.36	4.36, 5.86

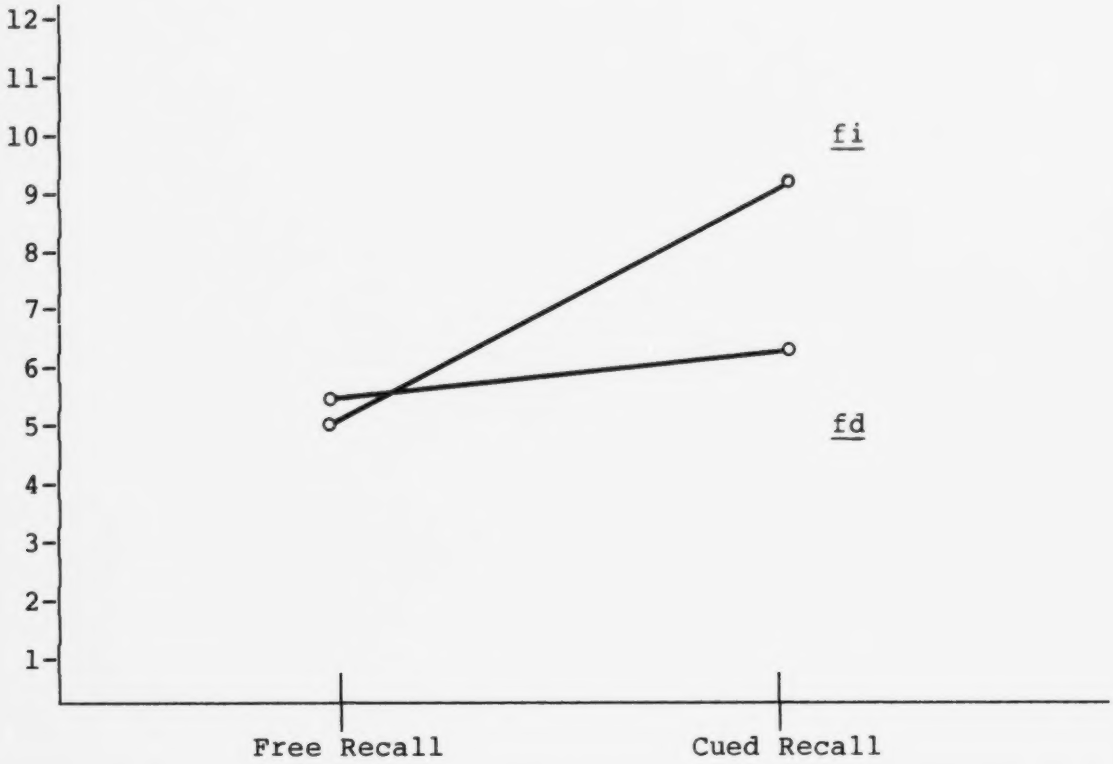
Test x fd,fi Means

(Free Recall)	(Cued Recall)
fi, 5.11	fi, 9.32
(Free Recall)	**(Cued Recall)**
fd, 5.5	fd, 6.18

Table 2: Significant Resulting Means, Visual Testing Experiment



(*figure 2*: Instruction x Test Interaction)



(figure 3: Test x fd,fi Interaction)

	LD, Vis.F. Line Drawing, Visual Feed.		DD, Vis.F. Detailed Drawing, Visual Feed.		LD, Ver.F. Line Drawing, Verbal Feed.		DD, Ver.F. Detailed Drawing, Verbal Feed.	
	fi	fd	fi	fd	fi	fd	fi	fd
List Learn								
Simple Concept								
Complex Concept								

Figure 4: Verbal testing, fdfi, Experimental Design

Source	Mean Sq.	Df	F-Ratio	P
Instruction (I)	34.89	3	.964	.41
fd,fi	128.76	1	3.56	.06
(I) x (fd,fi)	40.69	3	1.13	.34
Error	36.18	104	----	---
Tests (T)	171.74	2	28.88	.001
(I) x (T)	7.85	6	1.32	.25
(fd,fi) x (T)	5.32	2	.90	.35
(fd,fi) x (I) x (T)	6.03	6	.42	.39
Error	5.94	208	----	---

Table 3: ANOVR Summary Table Verbal Testing

List = 11.01; Simple Concept = 10.26; Complex = 9.13

Table 4: Significant Testing Means

Source	Mean Sq.	Df	F-Ratio	P
By Group	53.59	7	1.35	.23
Error	39.76	152	----	---
3-Sub Scales	576.34	2	32.99	.001
Interaction	16.87	14	.97	.49
Error	17.47	304	----	----

Table 5: ANOVR: Reflectivity Impulsivity Norms; Psuedo Experimental Design Results

3-Sub Scale Means		
Non-Planning	Motor	Cognitive
14.92	16.93	18.71

Table 6: Significant Reflectivity x Impulsivity Means

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Title:

Delay of Feedback and Cognitive Task Level in Practice Exercises.

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DELAY OF FEEDBACK AND COGNITIVE TASK LEVEL IN PRACTICE EXERCISES

by

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Running Head: Feedback in Practice

DELAY OF FEEDBACK AND COGNITIVE TASK LEVEL IN PRACTICE EXERCISES

Feedback is a key element in a sequence of instruction. It is the means by which a learner is able to judge his or her performance. Without feedback, a learner is left to perform with no sense of direction or measure of correctness.

Weiner first identified feedback in his book Cybernetics (1948). He envisioned systems that were goal-seeking, taking small steps toward a predetermined goal. Feedback was the information which returned to the system after each step so that the system could adjust performance on the next step in order to reach the specified goal. Thus, feedback served to determine the direction in which the next step was taken.

Feedback as a formal component of instruction became prevalent in the 1960's with the widespread use of programmed instruction. Learning theorists called for feedback as an integral part of the instructional process while instructional designers included feedback as a formal step in the instructional process.

Feedback has been studied widely since the 1960's. Researchers have found varying degrees of importance of feedback, as well as conflicting ideas in the ideal application of feedback for instructional purposes. At least some of the differences in opinion in feedback research can be attributed to the many dimensions of feedback and the difficulty that exists in trying to control all of these dimensions. This paper is concerned with the dimension of timing of feedback.

Timing of feedback refers to the amount of time that elapses between the student's response and the presentation of feedback. This interval may be immediate or it may be delayed 5 seconds, 5 minutes, an hour, or a day.

The Behaviorists' view of feedback (Robin, 1978; Skinner, 1968; Weiner, 1948) was that it served as a reinforcer. This point of view required that feedback be provided immediately after the desired behavior in order to reinforce the behavior and increase the likelihood that it would be repeated.

Brackbill and her associates (1962), in experiements with third grade boys, found that delaying the presentation of feedback for as little as 5 seconds contributed to the increase of scores on retention tests given 8 days after the initial learning. This increase in retention after a delay in feedback has been named the Delay-Retention Effect (DRE).

The explanation offered by Brackbill and her associates for the Delay-Retention Effect was that the delay of feedback provided greater resistance to forgetting. Sturges and Crawford (1964) proposed that the DRE could be explained by the fact that those receiving delayed feedback spent the delay interval rehearsing the questions. This verbal rehearsal theory was also proposed by Sturges (1969) and Sassenrath and Yonge (1968, 1969). However, no one was able to support this verbal rehearsal theory with research results.

Kulhavy and Anderson (1972) proposed the Interference Perseveration Theory (IPT) as the reason for the DRE. The IPT stated that

> ...learners forget their incorrect responses over the delay interval, and thus there is less interference with learning the correct answers from the feedback. The subjects who receive immediate feedback, on the other hand, suffer from proactive interference because of the incorrect responses to which they have committed themselves. (p.506).

While this explanation applies to answers that are initially incorrect, it does not apply to initially correct answers. "The delay is not an issue in the case of a positive feedback since there is no competing response." (Joseph and Maguire, 1982, p. 360)

The Interference Perseveration Theory has been supported by several researchers (Bardwell, 1982; Sassenrath, 1972, 1975; Sturges, 1978; Surber and Anderson, 1975). While others (Peeck, Van Der Bosch, and Kreupleling, 1985; Sassenrath & Yonge, 1968; Sturges, 1978; Tabachneck, 1982) have challenged the IPT, there have been no rival theories presented and supported.

The timing of feedback has been investigated extensively over the past twenty-five years, with most of the research completed in the mid-1970's. There has been a resurgence of feedback research, however, in the 1980's which reflects the interest in the effective design of computer-assisted courseware. Research on retention and the timing of feedback typically uses a paradigm that involves a pretest or initial exposure to the items, a delay interval before the feedback, an immediate posttest after the feedback, and a delayed posttest after another delay interval. (See Figure 1) The immediate posttest provides a measure of initial acquisition while the delayed posttest provides a measure of the retention of learning.

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Insert Figure 1 here

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One variable that has contributed to the research on delay of feedback is that of the cognitive level of the tasks on which feedback is provided. Many researchers have suggested that delayed feedback is better for the higher cognitive levels (Anderson, Kulhavy and Andre, 1971; Bardwell, 1982; Brackbill, 1964; Gaynor, 1981; Kulhavy and Anderson, 1972; Markowitz and Renner, 1966; Sturges, 1978), but few studies have been conducted to determine the relationship of timing of feedback and cognitive level of the task. Of those studies which have dealt with this topic (Gaynor, 1973, 1981; Pound, 1977; Quiring, 1971; Tabachneck, 1982), none have found a significant relationship between the timing of feedback and the cognitive level of the task.

This paper reports the findings of a study on the relationship of timing of feedback and three cognitive levels of the tasks completed. The tasks for this study were classified according to the cognitive levels used in Gagne's hierarchy of learning (1985). This hierarchy was chosen, as opposed to those proposed by other educators such as Bloom (1956), because 1) it is widely accepted in the field of instructional design, 2) it is based on the postulate that the mental processing required for each type of learning and retention is different, 3) there is a body of research that also uses this hierarchy, and 4) prior studies with accounting have classified the accounting tasks with this hierarchy.

This study differed from prior studies on the relationship of the timing of feedback and cognitive levels in that the tasks were of a hierarchial nature; that is, task 2 built on the knowledge gained in task 1. In addition, the study was conducted in multiple sessions over a five week period while most delay-of-feedback studies have used a single session for presentation of the learning. Finally, this study differed from prior studies in that the treatments and dependent measures were all administered on the computer.

The hypotheses for this study were:

H1 On the low cognitive level task, subjects in the immediate feedback group will score significantly higher on the delayed posttest than subjects in the next-session feedback group.

H2 On the high cognitive level task, subjects in the next-session feedback group will score significantly higher on the dealyed posttest than subjects in the immediate feedback group, after equating the two groups on knowledge from the prior tasks.

METHODS

Subjects

Subjects were 195 students from the Principles of Accounting I course at the University of Texas at Austin in the Fall of 1987. Four sections, taught by two assistant instructors, were designated by the supervising professor. One section was assigned as the control group. Students from the other three sections were randomly assigned to the three treatment groups as they entered the computer lab for the first time. Students who participated were given additional credit toward their final grade in the course.

Accounting was chosen as the topic for these exercises because there are a lot of concepts, rules, and problem-solving tasks that must be completed early in the Principles of Accounting course. This knowledge must be learned within the first four to five weeks of the semester. Without this basic knowledge, students are unable to understand the course content that follows and how it relates to their future careers.

Design

The study used a quasi-experimental design with subjects in four groups:

control--an intact section taking only the written pretest and a written delayed posttest

immediate feedback treatment group--took the written pretest, then completed 13 sessions on the computer, with feedback immediately after each incorrect answer

end-of-session (EoS) feedback treatment group--took the written pretest, then completed 13 sessions on the computer, with feedback on incorrect answers given at the end of each computer session

next-session feedback treatment group--took the written pretest, then completed 14 sessions on the computer, with feedback on incorrect answers given at the beginning of the next session following the session in which the exercise was completed

The tasks involved in the treatment sessions were classified into three cognitive levels:

Level 1 (low cognitive level): Defined Concept
    The task was classifying accounts
Level 2 (medium cognitive level): Rules
    The task was specifying debit or credit for an increase or decrease to accounts
Level 3 (high cognitive level): Problem-solving
    The task was choosing the correct adjusting entry, given a particular situation

Instruments

Four parallel tests for each of the three cognitive levels were developed. The written pretest was given on the second day of class to subjects in both the control and the treatment groups and contained questions on all three cognitive levels. A background questionnaire was completed on the same day.

The embedded pretest, the immediate posttest and the delayed posttest were given to the subjects in the three treatment groups as a part of their computer sessions. The delayed posttest was given to the control group as a written in-class activity, at approximately the same time in the semester as most of the treatment subjects took it.

A week after the study ended a followup questionnaire was completed by subjects in the three treatment groups.

Materials

The computer program used to provide the practice exercises was a researcher-designed program, based on a linear design. The design features of the program included instructions on each new task, a review of the in-class learning for the new task, single keystroke responses, feedback on incorrect answers only, and the requirement to hit the space bar before proceeding after feedback had been presented. The program was written in PC Pilot and operates on an IBM PC computer with monochrome monitor and 256K of memory. No other materials were necessary.

Each session contained a specified number of items for each cognitive level. (See Table 1) The items for each session were drawn from the item pool, with no item repeated in the same session, and with each item repeated three times in the course of the study. For the immediate and end-of-session treatment groups, 13 sessions were required to complete the exercises; for the next-session group, 14 sessions were required. (Table 2)

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Insert Tables 1 and 2 here
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Subjects were asked to complete no more than one session per day, with an average of three sessions per week in order to coordinate the exercises with their in-class learning.

Different screen designs were used for each of the three cognitive levels and their associated tasks. Figures 1, 2, and 3 show the three screen designs.

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Insert Figures 2,3,and 4 here
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As a subject pressed the key for his/her choice, the key was highlighted on the screen. Feedback was given only on incorrect answers. This feedback consisted of an arrow pointing to the correct answer. When feedback was given, subjects in the immediate feedback treatment group could still see the highlighted key which indicated their answer choice. End-of-session and next-session treatment groups were not shown their original answer when they were given feedback.

No feedback was given on the posttests and the items presented on the posttests were not counted as item repetitions.

Procedure

On the second day of class for the semester all groups were given the written pretest and the background questionnaire. Subjects in the three sections which were not the control group were told that several software designs were being tested and were asked to report to the computer lab within the next few days to begin their computer sessions.

As they entered the computer lab they took a disk from the front of the storage box, wrote their identifying number on it, and began work at the computer. Each disk was preprogrammed and contained the sessions appropriate to the treatment group. Thus, students were randomly assigned to a treatment group as they took their disk.

Students completed one session at a time, with no more than one session per day. At the end of each session their performance information was written to the disk and they refiled the disk. At their next session they took their disk and completed their work. Thus, subjects completed their work at their own pace. All sessions could be completed as early as the thirteenth day or as late as the end of the fifth week, which was the time limit for the study. Students were given a suggested time line and asked to stay as close to it as possible in order to maximize the effect of the computer-assisted exercises.

A week after the deadline for completion of the computer exercises, a questionnaire on the program design and student attitudes about it was completed by subjects who had done the exercises.

RESULTS

In order to determine if the groups were equivalent a One-Way Analysis of Variance was completed on the pretest scores for each of the three cognitive levels. These three ANOVAs indicated that there was no difference between the three treatment groups and the control group, nor among the three treatment groups. An additional Analysis of Variance was completed with the SAT scores for subjects in the four groups and it confirmed that there was no difference in the academic ability, as measured by the SAT, of the four groups.

In order to determine that the treatment was effective, a One-Way Analysis of Variance was completed on the delayed posttests for each cognitive level. On Level 1 and Level 2, all three treatment groups performed significantly better (at the .001 level) than did the control group. On Level 3, the immediate and end-of-session treatment groups performed significantly better than the control group, but the difference did not reach the .05 level of significance for the next-session treatment group.

Since the groups were shown to be equivalent and the treatment was effective, the control group was not included in the subsequent analyses.

In order to determine whether to reject the first null hypothesis, correlated t-tests were completed on the Written Pretest and the Delayed Posttest for Level 1. There was no significant difference in the F value for the immediate feedback treatment and the next-session feedback treatment on the low cognitive level. Therefore, the first null hypothesis was not rejected.

For the second null hypothesis, the hierarchial nature of the task had to be considered. Since the treatment might have provided an advantage to increase learning at the lower cognitive levels, thus affecting the learning at the higher cognitive levels, a correction factor for prior learning had to be employed. Thus, the embedded pretest was used for the correlated t-test with the delayed posttest, since the embedded pretest represented the level of knowledge of problem-solving that the subject had when beginning the problem-solving activity. The results of the correlated t-tests were not significant. Further, an Analysis of Variance of the Adjusted Gain Score (delayed posttest minus embedded pretest) yielded no significant difference between the treatments on the high cognitive level task and the second null hypothesis was not rejected.

Further analysis of the treatment was completed with high and low ability subjects. The high and low ability groups were based on those subjects with SAT scores .25 of a standard deviation above or below the mean. Analyses of Variance were completed on each group, but failed to yield any significant difference in the treatments.

An Analyis of Variance with low and high prior-knowledge groups, as shown by the total pretest scores, was also completed. Using the top and bottom quartiles of the pretest scores, ANOVAs were completed on the delayed posttest for each cognitive level. There was a significant difference for the three treatment groups on the low and the high cognitive level tasks. Table 3 indicates that the group by pretest interaction on the Low Cognitive Level was significant at the .05 level, while Table 4 indicates that the group by pretest interaction on the High Cognitive Level was significant at the .01 level.

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Insert Tables 3 and 4 here

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Figure 5 shows that on the Low Cognitive Level task, the next session feedback was more effective for the low prior-knowledge group than for the high prior-knowledge group. Figure 6 indicates that there was a significant advantage to high prior-knowledge subjects when using the end-of-session feedback for the High Cognitive Level task, while low prior-knowledge subjects suffered in using this treatment. In contrast, low prior-knowledge students performed better when using the next-session feedback while high prior-knowledge students did not perform as well.

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Insert Figures 5 and 6 here

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CONCLUSIONS AND RECOMMENDATIONS

The lack of significant results in this study might be attributed to several factors:

First, there was an apparent ceiling effect on the delayed posttest, as evidenced by the high mean scores. This ceiling effect was not evident on the pilot study of the materials completed; however, none of the pilot subjects were coenrolled in the Principles of Accounting course.

Second, the amount of knowledge gained through co-enrollment in the accounting course and its required readings and homework might have offset the effect of the treatment. In comparison to the course knowledge, the amount of knowledge transmitted via the exercises was very small. While this knowledge did contribute to superior performance on the posttest, when compared to the control group, much of this might be attributed to the additional time on task and the additional practice on items that appeared on the posttest.

Future research should include a replication of this study with students not co-enrolled in the accounting course. Instructional materials could be prepared which served to introduce the topics drilled on the computer exercises within this study.

Another recommendation would be the further refinement of these materials to include questions of a more difficult nature so as to alleviate the ceiling effect.

A recommendation for the improvement of accounting education would be to include computer-assisted drills during the study of the first four to five chapters. This recommendation is warranted by the high correlation of the scores on the delayed posttests of the treatment groups with the scores on the first course exam ($p = .002$). In addition, an ANOVA of the first exam scores between those who completed the treatments and those in the control group approached the level of significance. With the relatively small investment of time (mean time on the treatments was 144 minutes), there is a significant increase in course achievement. Of course, additional research should be completed in the area of computer-assisted accounting drills.

Finally, more research is needed in the area of the relationship of the timing of feedback and the cognitive task level in order to determine whether or not a relationship exists and if so, what that relationship is.

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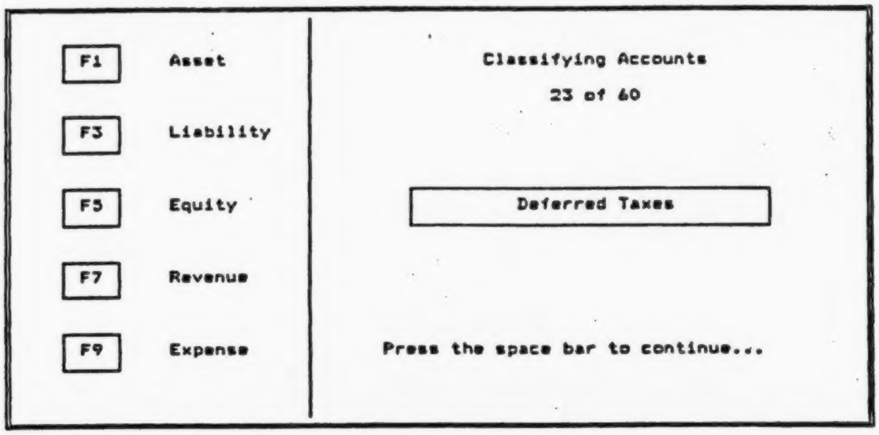
T1 _ _ _ _ _ _ _ _ _ _ _ _ F T2 _ _ _ _ _ _ _ _ _ _ _ _ T3

d1 r1

T1 = initial exposure to the item
d1 = delay interval before feedback
F = feedback
T2 = immediate posttest
r1 = retention interval before delayed posttest
T3 = delayed posttest

Figure 1

Paradigm for Delay-Retention Effect Research Studies



F1
Asset
F3
Liability
F5
Equity
F7
Revenue
F9
Expense

Classifying Accounts

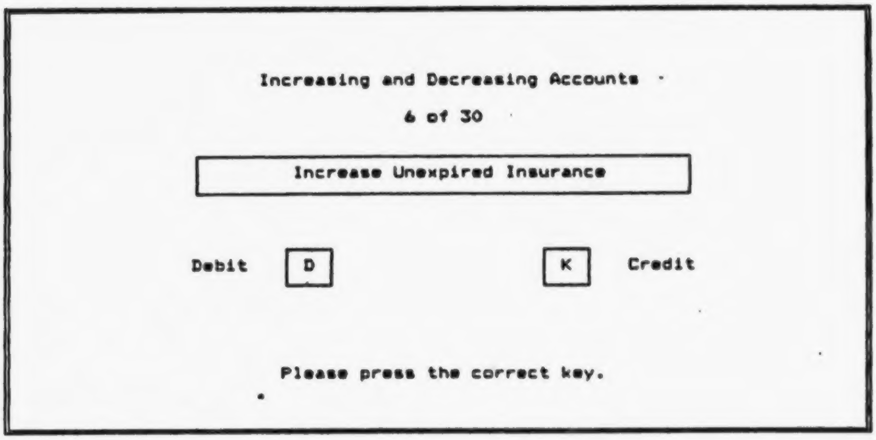
23 of 60

Deferred Taxes

Press the space bar to continue...

Figure 2

Screen Design for Low Cognitive Level Task (Classifying Accounts)



Increasing and Decreasing Accounts

6 of 30

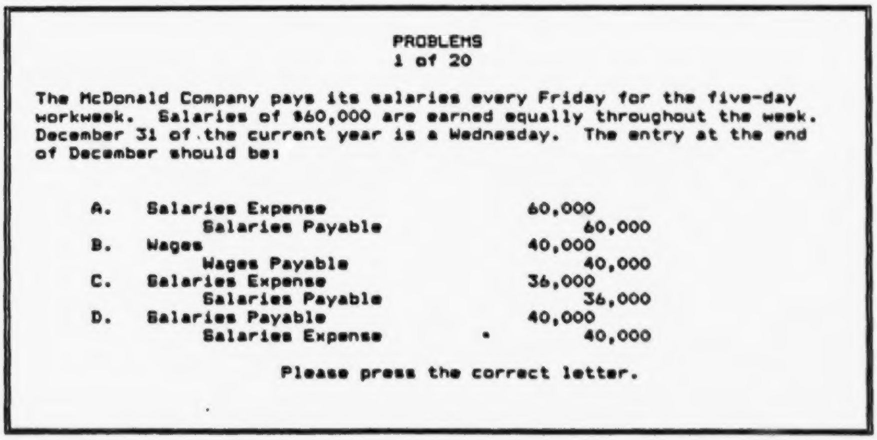
Increase Unexpired Insurance

Debit D K Credit

Please press the correct key.

Figure 3

Screen Design for Medium Cognitive Level Task (Increasing/Decreasing Accounts)



PROBLEMS
1 of 20

The McDonald Company pays its salaries every Friday for the five-day workweek. Salaries of $60,000 are earned equally throughout the week. December 31 of the current year is a Wednesday. The entry at the end of December should be:

```
A.   Salaries Expense              60,000
          Salaries Payable                  60,000
B.   Wages                         40,000
          Wages Payable                     40,000
C.   Salaries Expense              36,000
          Salaries Payable                  36,000
D.   Salaries Payable              40,000
          Salaries Expense                  40,000
```

Please press the correct letter.

Figure 4

Screen Design for High Cognitive Level Task (Problem Solving)

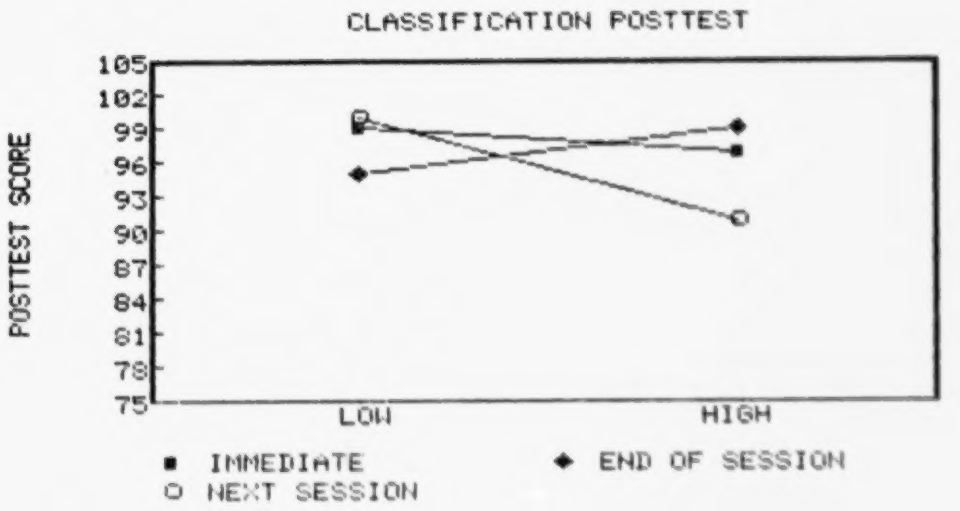


Figure 5

Low Cognitive Level Delayed Posttest Scores by Treatment Group for Low and High Quartiles on Written Pretest

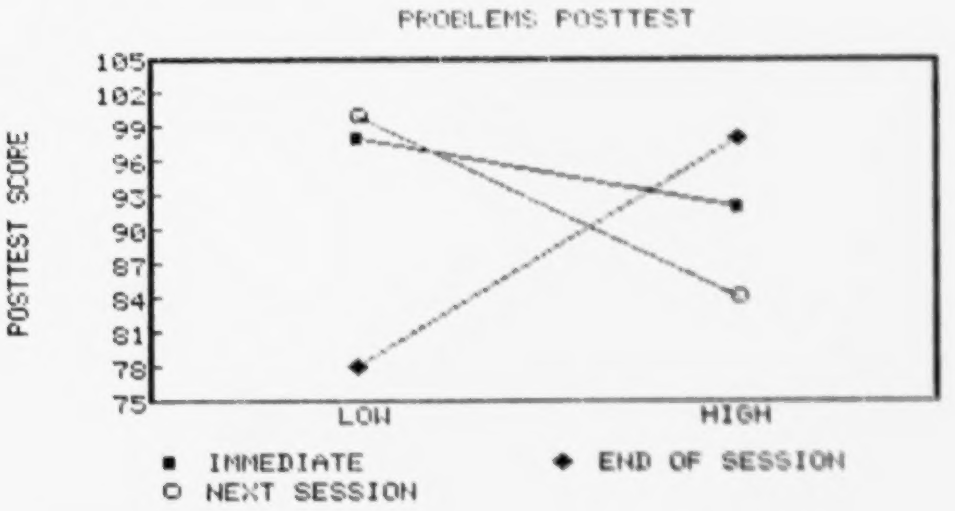


Figure 6

High Cognitive Level Delayed Posttest Scores by Treatment Group for Low and High Quartiles on Written Pretest

Table 1

Paradigm Summary for Immediate and EOS Treatment Groups

Session	Level 1 Classify	Level 2 IncDec	Level 3 Problems	Daily Total
1	60			60
2	30			30
3	20	60		80
4	20	80		100
5	20	70		90
6	20	50	10	80
7	10 & ipt	40	20	70
8		30	20	50
9		30 & ipt	10	40
10	dpt		10	10
11			10	10
12		dpt	10 & ipt	10
13			(a) dpt	
Total	180	360	90	630

	Item Repetitions to Total Items in the Pool		Number of Sessions
Classify	180:60	3.0	7
IncDec	360:120	3.0	7
Problems	90:30	3.0	7

ipt = immediate posttest
dpt = delayed posttest

(a) This session will be one week after the prior session.

Table 2

Paradigm Summary for Next Session Delayed Treatment Group (a)

Session	Level 1 Classify	Level 2 IncDec	Level 3 Problems	Daily Total
1	60			60
2	30			30
3	20	60		80
4	20	80		100
5	20	70		90
6	20	50	10	80
7	10	40	20	70
8	ipt	30	20	50
9		30	10	40
10		ipt	10	10
11	dpt		10	10
12			10	10
13		dpt	ipt	
14 (b)			dpt	
Total	180	360	90	630

	Item Repetitions to Total Items in the Pool		Number of Sessions
Classify	180:60	3.0	7
IncDec	360:120	3.0	7
Problems	90:30	3.0	7

ipt = immediate posttest
dpt = delayed posttest

(a) This paradigm is one session longer than that of the other treatment groups since the next session delayed group must come in for feedback one day after they complete the exercises. Thus, their immediate posttest on the problems is given one day later than the other groups.

(b) This session will be one week after the prior session.

Table 3

ANOVA of Treatment Group by Low and High Quartiles on Written Pretest Scores for Low Cognitive Level Task

Source	df	Mean Square	F	p
Main Effects	3	47.65	.839	.479
Group	2	34.72	.612	.547
Posttest	1	72.59	1.279	.264
Interactions				
Grp X Posttest	2	181.76	3.202	.050*
Explained	5	101.30	1.784	.134
Residual	48	56.77		
Total	53	60.97		

* p < .05

Table 4

ANOVA of Treatment Group by Low and High Quartiles on Written Pretest Scores for High Cognitive Level Task

Source	df	Mean Square	F	p
Main Effects	3	184.69	1.331	.275
Group	2	277.02	1.997	.147
Posttest	1	5.93	0.043	.837
Interactions				
Grp X Posttest	2	1478.15	10.653	.001**
Explained	5	702.07	5.060	.001
Residual	48	138.75		
Total	53	191.89		

** p < .01

Title:

The Effects of Feedback, Correctness of Response, and Reponse Confidence on Learner's Retention in Computer-Assisted Instruction

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The Effects of Feedback, Correctness of Response, and Response Confidence on Learner's Retention in Computer-Assisted Instruction

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THE EFFECTS OF FEEDBACK, CORRECTNESS OF RESPONSE, AND RESPONSE CONFIDENCE ON LEARNER'S RETENTION IN COMPUTER-ASSISTED INSTRUCTION

The role of microcomputer technology in the educational process is of an increasing interest among educators. In educational computing, computer-assisted instruction (CAI) is seen by many educational leaders as a cost-efficient and effective method of instruction (Nelson, 1985-86). Clark (1983) states that the novelty of CAI motivates student's learning. The novelty effect, however, usually wears off after a few weeks. Waldrop (1984) suggests that instructional designers cannot rely solely on the computer as a prime source of reinforcement. Rather, the source of reinforcement should come from the content and structure of CAI through the systematic application of sound principles of learning.

One important element in the design of computer-assisted instruction is feedback. The ability to give appropriate and timely feedback has often been cited as an advantage of CAI (Magidson, 1977; Dence, 1980). Because of the increasing demand for quality CAI, there is a need to investigate the effects of feedback within the context of CAI (Carter, 1984).

Although it has been widely accepted among educators that feedback facilitates learning in many teaching situations, no decisive agreement has been made regarding how feedback acts to promote learning and retention. According to operant psychologists, feedback following a correct response reinforces and thus increases the probability that the response will be made again in the future (Bigge, 1982). However, research has indicated that feedback operates primarily to correct errors rather to reinforce correct response as claimed by operant psychologists (Guthrie, 1971; Anderson, Kulhavy, & Andre, 1972; Roper, 1977, Bardwell, 1981).

Most of the studies in the area of instructional feedback have been conducted to investigate the effects of different types of feedback on learning. Few attempts, however, have been made to consider the effects of adapting the feedback strategy to match a learner's specific needs at the moment of learning. Traditionally, feedback is provided to the learner based on the correctness of his response; and the same type of feedback is given to the learner throughout the lesson regardless of his response. Some educators suggest, however, that in self-instructional material, feedback that is provided to the learner should be "specific" to the performance being made (Smith & Smith, 1966; Caldwell, 1980).

Feedback research has suggested that the learner's response confidence affects the way in which he uses feedback information (Kulhavy, Yekovich & Dyer, 1976; 1979). Kulhavy, et al. (1976) conducted a study to investigate the relationship between feedback, confidence, and postresponse behavior. It was found that feedback study times were shortest for correct responses with high confidence, longest for incorrect responses with high confidence, and somewhere in between for responses with low confidence. Responses with high confidence were remembered more accurately on the tests regardless of the correctness of the responses. No major differences were found between the two groups regarding responses with low confidence. From the results of the study, Kulhavy (1977) suggested that the interaction between feedback and learner expectation in terms of his or her response confidence could provide a powerful effect on learner's retention. He also suggested that the learner's confidence in the response might be used as a basis for an effective design strategy for providing feedback, especially when the instruction was under the control of computer.

Based on the results of the study conducted by Kulhavy, et al. (1976), knowledge of learner's response confidence and correctness of response may be used in identifying the type of feedback which will be appropriate to the learner's postresponse behavior. The model in figure 1 represents a hypothetical framework for presenting feedback in CAI lesson. There are four possible conditions for each response.

1) Correct Response with High Confidence

For this condition, only the knowledge of results (KOR) feedback ("Correct") will be needed for providing confirmation of the correct answer. Additional information is not necessary since the learner answered correctly and had confidence in the answer.

2) Correct Response with Low Confidence

Under this condition, telling the learner that his or her response was correct may not be sufficient. Additional information in the feedback message would seem to be needed to increase the level of confidence. Consequently, the knowledge of results and positive response-contingent feedback (a statement of why the response is correct) would be given to the learner.

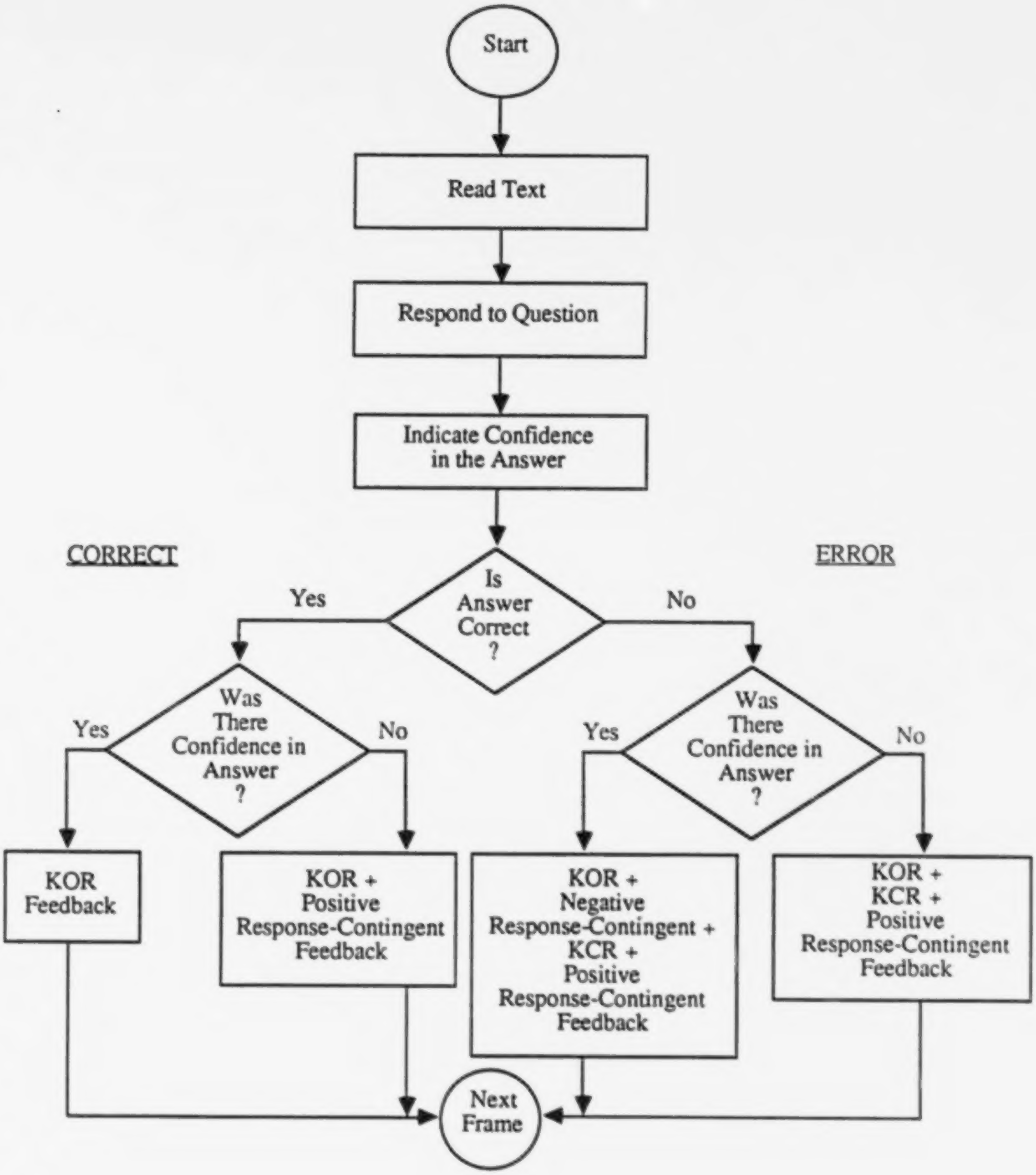
Start
Read Text
Respond to Question
Indicate Confidence in the Answer
CORRECT
ERROR
Yes
Is Answer Correct ?
No
Yes
Was There Confidence in Answer ?
No
Yes
Was There Confidence in Answer ?
No
KOR Feedback
KOR + Positive Response-Contingent Feedback
KOR + Negative Response-Contingent + KCR + Positive Response-Contingent Feedback
KOR + KCR + Positive Response-Contingent Feedback
Next Frame

Figure 1

Hypothetical Design Model for Providing Feedback in a CAI lesson

3) Incorrect Response with High Confidence

For this condition, additional feedback information will be necessary to correct error response. As suggested by Echternacht, Boldt and Sellman (1971), the learner should first be shown why the alternative selected was incorrect; and, after he or she is convinced of the error, be shown why the keyed answer is, in fact, correct. Consequently, for this condition, the learner will be given knowledge of the results, plus negative response contingent feedback (a statement of why the response is incorrect), plus knowledge of the correct response (feedback of correct choice), plus positive response-contingent feedback (a statement of why the keyed answer is correct).

4) Incorrect Response with Low Confidence

For this condition, the learner should be shown why the correct answer is correct (Echternacht, Boldt, & Sellman; 1971). Thus the learner will be given knowledge of results ("incorrect"), plus knowledge of correct response (feedback of correct choice), plus positive response-contingent feedback (a statement of why the keyed answer is correct).

Purpose of the Study

The purpose of this study is to examine within the context of CAI, the effects of feedback, correctness of response, and response confidence on learner's retention of verbal information. The model in Figure 1 was used as a design strategy for providing feedback in this study.

Specifically, the questions investigated in this study are:

1. Does feedback which is based both on the correctness of response and learner's confidence help to promote student's retention of learned material?
2. Does feedback following a correct response serve to ensure that a correct response will be made on a later test?
3. Does feedback following an incorrect response serve to correct the mistake and ensure that a correct response will be made on a later test?
4. Do different levels of confidence interact with feedback following a correct response which may serve to ensure that a correct response will be made on a later test?
5. Do different levels of confidence interact with feedback following an incorrect response which may serve to correct mistake and ensure that a correct response will be made on a later test?

It was expected on both immediate and delayed posttests that the feedback group would perform significantly better than the no feedback group with respect to the following dependent variables:

1. overall correct responses
2. conditional probability of a correct response on a test given that a correct response was made on the lesson -- $P(R_t|R_l)$
3. conditional probability of a correct response on a test given that an incorrect response was made on the lesson -- $P(R_t|W_l)$
4. conditional probability of a correct response on a test given that a high-confidence correct response was made on the lesson -- $P(R_t|RH_l)$
5. conditional probability of a correct response on a test given that a low-confidence correct response was made on the lesson -- $P(R_t|RL_l)$
6. conditional probability of a correct response on a test given that a high-confidence incorrect response was made on the lesson -- $P(R_t|WH_l)$
7. conditional probability of a correct response on a test given that a low-confidence incorrect response was made on the lesson -- $P(R_t|WL_l)$

Method

Subjects

One hundred and twenty-three students enrolled in four Computer Literacy classes at the University of Texas volunteered to serve as subjects for the study. Due to some errors in recording data onto the diskettes, only one hundred and twenty subjects successfully completed the experiment. The majority of the subjects were upper division education students.

Materials

The instructional material for this study was "The Structure and Function of the Human Eye" published in the book entitled "Programmed Instruction: Techniques and Trends (O'Day, Kulhavy, Anderson & Malczynski; 1971). This experimental material was also used in the study conducted by Kulhavy, et al. (1976). There are thirty program frames with three alternative multiple-choice questions relating to the content of the lesson. Additionally, there are six text-related drawings for use at designated points within the lesson. The type of instructional task was the recall of verbal information.

Feedback Messages. Since different types of feedback message were to be provided to subjects, based upon the correctness of response and response confidence, the feedback messages for each alternative on each question were written by the researcher. These feedback messages were evaluated and criticized by two doctoral students in the department of Science Education at the University of Texas at Austin.

A sample frame and question in the program published in the book entitled "Programmed Instruction: Techniques and Trends (O'Day, Kulhavy, Anderson & Malczynski; 1971) are as follows:

> The rods adapt to dimmer light conditions by means of a visual pigment they contain. . . called rhodopsin. Rhodopsin is often called visual purple because of its characteristic dark blue color. The raw material from which rhodopsin is made is vitamin A, and, thus, a deficiency of vitamin A will result in poor dim-light vision.
>
> Which of the following statements regarding rhodopsin is true?
> (1) It contains a pigment called visual purple.
> (2) It becomes deficient in the presence of vitamin A.
> (3) It is dark blue in color. (p. 163)

The following is an example of feedback message for the instructional frame presented above.

Selected Answer	Level of Confidence	Feedback Message
1	High	Incorrect. Rhodopsin does not contain visual purple. Rhodopsin is often called visual purple. The correct answer is "3". Rhodopsin is often called visual purple because of its characteristic dark blue color.
1	Low	Incorrect. The correct answer is "3". Rhodopsin is often called visual purple because of its characteristic dark blue color.
2	High	Incorrect. Rhodopsin is made from vitamin A. Rhodopsin becomes deficient in the absence of vitamin A. The correct answer is "3". Rhodopsin is often called visual purple because of its characteristic dark blue color.
2	Low	Incorrect. The correct answer is "3". Rhodopsin is often called visual purple because of its characteristic dark blue color.
3	High	Correct.
3	Low	Correct. Rhodopsin is often called visual purple because of its characteristic dark blue color.

Lesson Development. The programming language used in the development of the CAI lesson for this study was SuperPILOT authoring language. Two computer programs were developed in order to present the material. One program was for the no feedback condition, the other was for the feedback condition. For each frame of instruction on the lesson for the no feedback condition, the computer displayed the text screen, recorded the time the subject spent on reading text, displayed the question screen, recorded the response and the response time, and recorded the confidence in the response. Additionally, the program for the feedback condition displayed the feedback message based on the correctness of the response and the subject's response confidence. It also recorded the time that a subject spent on studying the feedback message for each frame. All data for each subject were stored in the data file on the diskette. Time was recorded in numbers of seconds. Since it took a few seconds for the computer to complete filling all the text onto the screen, and since the timer started after the last line of text displayed, the times measured were approximations and should be used as relative rather than absolute measures.

Assessment Instruments. Both immediate and delayed retention measures consisted of the same thirty questions seen in the CAI lesson. However, on both tests the sequence of these questions was randomized. Posttests were paper-and-pencil type tests. On these retention tests, subjects were not asked for response confidence.

Procedures

The experiment was conducted during a regularly scheduled class period in a computer classroom equipped with 41 Apple II computers. All students in a given class were randomly assigned to either the no feedback or the feedback condition. At the beginning of the class, the request for volunteers was made by the class instructor. All students were informed that their regular class grade would not be affected by their performance on the experiment. They were also told that they were not required to participate in the study. However, they would have had to do an alternative assignment during the class had they chosen not to participate. All students attending the class on the days of the experiment volunteered to be part of the study.

Each subject was given the six drawings to be used with the CAI lesson. At the beginning of the lesson, they were asked to type their names. Then they were informed of what they could expect from the lesson. They were initially told that there were thirty frames of instruction in the lesson. Each frame consisted of one screen of text and one screen of question relating to the content of the text. They were instructed to press the "Return" key when they finished reading the text screen. They would then see a screen displaying a multiple-choice question and were asked to enter their response to that question by pressing a number of their choice from 1 to 3. The computer would, at this point, ask them to enter their confidence in the choice they just made. They were instructed to enter "1" which represented "low confidence" if they were not quite sure that their answer was a correct one. If they felt positive that their answer was correct, they were instructed to enter a "2" which represented "high confidence". For the subjects in the no feedback condition, they were told that after they entered the number signifying their degree of confidence in the answer, they would receive a new frame of instruction. Subjects in the feedback group were also told that they would be given a message regarding their answer to question asked, and that they had to press the "Return" key after they finished reading the message.

Upon the completion of the CAI lesson, the diskette and the six drawings were collected by the researcher, and the immediate posttest was administered. One week after the experimental session, the delayed posttest was given to the subjects during the regularly scheduled class period. Since seventeen subjects did not attend the classes on the days of the delayed posttest administration, only one hundred and three subjects took the delayed test. As noted by Borg and Gall (1983), sampling bias may be expected in studies reporting large losses of subjects, for the subjects who remain with the study until its completion may be different from those who drop out. For both those who did and did not take the delayed posttest, analysis of variance was performed on the items answered correctly within the CAI lesson. This was performed to determine whether this study was subjected to sampling bias. The result indicated that there was no significant difference between the subjects who took the test and those who did not ($F = 2.1429$, $p = .1459$).

With respect to procedures, the differences between the study conducted by Kulhavy et al. (1976) and this study are as follows:

1) Form of Instruction

In the study by Kulhavy et al. (1976), the instruction was in the form of programmed instruction. The text and its question were on the same page. The subjects could refer back to the text while they were answering the question. In this study, the instruction was in the form of computer-assisted instruction. The text and its question were on separate screens. After the subjects turned to the question screen, they could not go back to the previous text screen.

2) Feedback Procedure

In the study by Kulhavy et al. (1976), the subjects in the feedback condition received Knowledge of Correct Response (KCR) feedback by erasing opaque circles on the response card until they located the correct choice for the particular question. In this study, the subjects in the feedback condition received different feedback messages based upon the correctness of their response and their confidence in the response.

3) Rating of Confidence

The subjects in the study by Kulhavy et al. (1976) rated their confidence on a scale of five, whereas the subjects in this study recorded their confidence on a scale of two (high or low).

Design

The design of this study was a posttest only control group design. The design was represented by the following diagram:

$$\begin{array}{lllll} R & O_1 & X & O_2 & O_3 \\ R & O_1 & & O_2 & O_3 \end{array}$$

where R = random assignment
X = experimental treatment (feedback)
O_1 = practice items on the lesson
O_2 = immediate posttest
O_3 = delayed posttest

Data Analysis

All statistical analyses were performed by using SPSS^x (1986) on an IBM 3081 computer at the University of Texas at Austin.

Analysis of Overall Correct Responses. In order to determine the effects of feedback which was provided on the basis of correctness of response and response confidence, one-way analysis of variance was performed on the overall correct responses for the feedback and no feedback groups on each posttest.

Analysis of Conditional Probabilities. Following the procedure used by Kulhavy et al. (1976), conditional probabilities relating lesson performance to the immediate and delayed posttests were calculated to determine the effects that feedback following a correct response had on both posttests. The conditional probability of a correct response on the test given that a correct response was made on the lesson, $P(R_t|R_l)$, is the proportion consisting of the number of responses which were correct on the test and were also correct on the lesson ($R_t \cap R_l$), divided by the total number of responses which were correct on the lesson (R_l). This conditional probability was also calculated for high and low confidence correct responses on the lesson.

To determine the effects that feedback following an incorrect response had on immediate and delayed retentions, conditional probabilities relating lesson performance to the two posttests were calculated. The conditional probability of a correct response on the test given that an incorrect response was made on the lesson, $P(R_t|W_l)$, is the proportion consisting of the number of responses which were correct on the test and were incorrect on the lesson ($R_t \cap W_l$), divided by the total number of responses which were incorrect on the lesson (W_l). This conditional probability was also calculated for high and low confidence correct responses on the lesson. Since the resulting conditional probability data were proportional data, they had to be transformed by using the arc sine function (Dowdy & Wearden, 1983). To test for statistical difference between the feedback conditions, a multivariate analysis of variance was performed on the transformed conditional probability data for each posttest.

Results

Overall Correct Responses

Table 1 shows the means and standard deviations for overall correct responses on the posttests. When the means on the immediate posttest were compared using a one-way analysis of variance, a statistical significant difference was found between the feedback conditions, $F(1,118) = 17.81$, $p < .001$, with those who receiving feedback performing significantly better than the no feedback group. When the means on the delayed posttest were compared, no significant difference was found between the feedback conditions, F (1,101) = 1.70, p = .19.

In order to determine if there were significant differences between the feedback conditions regarding the performance on lesson, a one-way analysis of variance was calculated on the mean of three variables: number of correct responses on the lesson, text reading time, and response time. No significant differences were found on the analyses of the number of correct response and the response time. A significant difference was found between the feedback conditions with respect to the variable text reading time. The no feedback group spent significantly more time reading text frame than the feedback group, F (1,118) = 9.91, p < .01.

Table 1
Means and Standard Deviations for Correct Responses on Posttests

Test Position	Feedback Condition	
	Absent	Present
Immediate		
M	22.08	24.97
SD	4.34	3.02
Delay		
M	19.50	20.48
SD	4.89	5.11

Conditional Probability Measures

From the multivariate analysis of variance (MANOVA) performed on the means of the six transformed conditional probabilities on the immediate posttest, a significant difference was found between the feedback conditions (Wilks' lambda = .39321, F = 22.37550, Sig. of F < .001). Table 2 presents the univariate F-tests on the conditional probabilities.

Table 2
Analysis of Conditional Probability Measures on the Immediate Posttest

Variable	Group	N	Mean	Transformed Mean	SD	F	Sig. of F
$P(R_t \mid R_l)$	NFB	46	0.83	1.01	0.22	1.56	0.22
	FB	48	0.85	1.07	0.23		
$P(R_t \mid RH_l)$	NFB	46	0.86	1.10	0.25	0.00	0.99
	FB	48	0.87	1.10	0.22		
$P(R_t \mid RL_l)$	NFB	46	0.72	0.93	0.46	1.85	0.18
	FB	48	0.79	1.06	0.45		
$P(R_t \mid W_l)$	NFB	46	0.25	0.25	0.18	130.24	0.00
	FB	48	0.74	0.90	0.34		
$P(R_t \mid WH_l)$	NFB	46	0.22	0.26	0.36	79.16	0.00
	FB	48	0.77	1.05	0.49		
$P(R_t \mid WL_l)$	NFB	46	0.25	0.29	0.36	49.47	0.00
	FB	48	0.70	0.90	0.47		

The result of MANOVA performed on the means of the six transformed conditional probabilities on the delayed posttest also indicated a significant difference between the feedback conditions (Wilks' lambda = .62392, F= 7.43408, Sig. of F < .001). The results of the univariate F-tests were presented in Table 3.

Table 3
Analysis of Conditional Probability Measures on the Delayed Posttest

Variable	Group	N	Mean	Transformed Mean	SD	F	Sig. of F
$P(R_t \mid R_l)$	NFB	40	0.68	0.77	0.19	0.01	0.94
	FB	41	0.68	0.77	0.19		
$P(R_t \mid RH_l)$	NFB	40	0.71	0.82	0.24	0.65	0.42
	FB	41	0.69	0.78	0.21		
$P(R_t \mid RL_l)$	NFB	40	0.60	0.72	0.42	0.09	0.77
	FB	41	0.62	0.75	0.43		
$P(R_t \mid W_l)$	NFB	40	0.34	0.35	0.20	40.58	0.00
	FB	41	0.60	0.67	0.25		
$P(R_t \mid WH_l)$	NFB	40	0.39	0.48	0.47	9.88	0.00
	FB	41	0.64	0.80	0.46		
$P(R_t \mid WL_l)$	NFB	40	0.26	0.28	0.27	18.89	0.00
	FB	41	0.53	0.64	0.45		

The results regarding the probability of correct response on the test given that a **correct** response was made on the lesson, $P(R_t|R_l)$ on both the immediate and delayed posttests indicated no significant difference between the feedback conditions. When the correct responses on the both posttests were analyzed further on the basis of learner's confidence in the response made on the lesson, no significant differences were found between the groups concerning the probability of correct response on the test given that a correct response with **high confidence** was made on the lesson, $P(R_t|RH_l)$. The same results were found on both posttests for the probability of correct response on the test given that a correct response with **low confidence** was made on the lesson, $P(R_t|RL_l)$.

The results on both immediate and delayed posttests indicated that there was a significant difference between the no feedback and feedback groups ($p < .001$) regarding the probability of correct response on the test given that an **incorrect** response was made on the lesson, $P(R_t|W_l)$. When the correct responses on the test were analyzed further on the basis of learner's confidence in the response made on the lesson, it was found that there was significant difference between the two groups ($p < .001$) regarding the probability of correct response on the test given that a **high confidence** incorrect response was made on the lesson, $P(R_t|WH_l)$. For the probability of correct response on the test given that a **low confidence** incorrect response was made on the lesson, $P(R_t|WL_l)$, a significant difference was also found between the feedback and no feedback group ($p < .001$).

Discussion

Overall Correct Responses on Posttests

With respect to the overall correct responses on the immediate posttest, the feedback group performed significantly better than the no feedback group. However, no significant difference was found on the delayed posttest. The findings indicate that feedback helps to promote the subject's retention of learned material at least on the immediate retention.

The overall correct responses, then, were analyzed further to examine how feedback helps to increase the correct responses on the posttest by focusing on the effects of feedback following correct and incorrect responses on the lesson.

Feedback Following Correct Responses

It was hypothesized that providing feedback after correct responses would confirm the subjects that their understanding of the material was accurate and thus ensure that the same correct responses would be made on a later test. The analyses on both immediate and delayed posttests regarding the conditional probability of a correct response on the immediate posttest given that a correct response was made on the lesson did not support the above hypothesis. This result is similar to the result found in Guthrie's study (1971). Guthrie also found that providing feedback after a correct response did not increase the probability that the correct response would also be correct on a later test. However, a contradicting result was found in the study conducted by Kulhavy et al. (1976). In their study, it was found that the subjects who received feedback after a correct response were more likely to remember their correct responses on a subsequent test.

When the level of learner's confidence in the response was taken into account, the results of the present study indicate that knowledge of results (KOR) feedback provided for a high-confidence correct response on the lesson does not increase the probability that the answer would be correct again on the posttests. The findings also contradict the findings in the study by Kulhavy et al. (1976). For a low-confidence correct response, it was hypothesized that the positive response-contingent feedback (a statement of why the response is correct) in addition to KOR would help the acquisition of material, increase their confidence, and thus promote the retention of the learned material. The results of the study also fail to support this hypothesis.

The findings of the study regarding the effects of feedback following correct responses indicate that regardless of confidence in the response feedback does not help to increase the probability that a correct response will also be correct on a later test. One possible explanation for the results is probably due to attention effect. Attention plays an important role in learning from written materials (Anderson, 1970). It was found in this present study that the subjects in the no feedback group spent significantly more time reading text frame than those in the feedback group. Since the subjects in the no feedback did not receive additional help from feedback, they probably spent more time and effort in order to comprehend the material before they turned to the question. Research about the effect of comprehension depth and memory suggests that deeper comprehension of material is associated with better retention (Mistler-Lachman, 1974). The increased attention in the no feedback group probably attributed to the lack of significant effects of feedback following the correct response.

Feedback Following Incorrect Responses

It was hypothesized that feedback following incorrect responses would serve to correct error and ensure that a correct response would be made again on a later test. A significant difference was found between the feedback conditions regarding the conditional probability of a correct response on the each posttest given that an incorrect response was made in the lesson. Therefore, these findings support the hypothesis that feedback following incorrect responses increases the probability that the response will be correct on a later test. Similar results were also found in the study conducted by Guthrie (1971). In the study by Kulhavy et al. (1976), however, no significant difference was found between the feedback and no feedback group with respect to this conditional probability. The difference in the procedure between this present study and Kulhavy's study may account for the difference in the results. In Kulhavy's study, the subjects received knowledge of correct response (KCR) feedback and they could refer back to the text to locate their error. In the present study, the subjects received not only the KCR but also an explanation of why the response was not correct.

When the level of learner's confidence in the response was taken into account, a significant difference was found between the feedback and no feedback group regarding the conditional probability of a correct response on each posttest given that a high-confidence incorrect response was made on the lesson. The results indicated that feedback following a high-confidence incorrect responses helps the subject to correct errors. Similar results were also found in the study conducted by Kulhavy et al. (1976). With respect to the conditional probability of a correct response on the test given that a low-confidence incorrect response was made in the lesson, a significant difference was also found between the feedback and no feedback groups. Therefore, feedback following a low-confidence incorrect response also helps to correct error. However, no significant difference was found in the study conducted by Kulhavy et al. (1976). Again the difference between the results of their study and the present study is probably due to the differences in the procedure of the two studies. Another possible explanation might be the difference in the rating scale of learner's confidence in the response. In Kulhavy's study, the subjects rated their confidence on a scale of 5. In this present study, the subjects recorded their confidence either high or low.

Overall, the findings of the study suggest that feedback helps to promote immediate retention of verbal information. Regardless of the learner's confidence in the response, feedback following an incorrect response had significant effects on both immediate and delayed retention of the learned material. With respect to the function of feedback, the findings of this study seem to be consistent with previous feedback research which indicate that feedback functions as a guide for identifying and correcting error.

There are several recommendations for future research suggested by the finding of this study. First, it will be interesting to see whether the results will be replicated in similar studies conducted in the conditions as closely as possible to the actual classroom setting.

Other suggestions for further research, with respect to the experimental design, include a replication of this study which might include larger sample size in order to incorporate more treatment groups in the experimental design. For example, the design of this present study can be extended to include two more feedback groups: a group that will receive only Knowledge of Results (KOR) feedback regardless of the correctness of response or learner's confidence, and another group that will receive feedback which explains why an answer is correct or incorrect. Such a design would be appropriate in determining whether the provision of feedback information on the basis of correctness of response and learner's confidence is better than simply providing the same type of feedback to learners. Another variation in terms of the design might be to examine whether offering a chance for the learner to review the material after incorrect response and correct the mistake by himself will be as effective as providing feedback explaining why his answer is incorrect.

With respect to data analysis, it is recommended that research in the area of instructional feedback should include the conditional probability measure in the analysis. The use of such measure allows the researchers to examine the effects of feedback following correct and incorrect response separately.

Finally, future research is needed to examine the effects of feedback on retention across different types of learning outcomes. The learner's need of feedback information for one type of learning outcome may not be the same for another. The intended learning outcome emphasized in this study was verbal information. Future research might focus on the effects of feedback, correctness of response, and learner's confidence on retention of other types of learning outcomes such as intellectual skills and cognitive strategies as designated by Gagne (1977).

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Title:

Instructional Development and Teacher Education: A Naturalistic Study

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A Naturalistic Study

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Instructional Development and Teacher Education

Several years ago, in an article in ECTJ, Sharon Shrock (1985) described her research on teacher attitudes towards instructional development. Shrock explained that ignorance of such attitudes is one reason that "in spite of our conviction that our technology could dramatically improve learning, most elementary, secondary, and college instruction proceeds today as it always has" (p. 16). Shrock went on to call for further research on teacher attitudes towards instructional development.

Recently, undergraduate education, including undergraduate teacher education, has been a primary target for reformers. This movement to reform undergraduate teacher education is likely to involve instructional development faculty working in university settings. Without an understanding of teacher educator's perceptions about instructional development, the efforts of instructional developers are as likely to create ill-will as improved teacher education programs.

In this study faculty beliefs about instructional development and teacher education were investigated. Nine faculty members participated in this study, all of whom teach in the school of education of a large state university. These respondents included five undergraduate methods teachers and four instructional development teachers. This semester-long study was emergent in design and was conducted primarily through interviews.

Methodology

The methodology of naturalistic inquiry was used in this study (Lincoln and Guba, 1985). In her own naturalistic study of faculty perceptions of ID, Shrock (1985) listed the following features of a naturalistic methodology: "The collecting of data occurs in real world settings in the relative absence of a priori assumptions. Data collection and analysis proceed simultaneously with additional data sources pursued on the basis of preliminary results" (p.18).

As with most naturalistic studies, the design of this inquiry emerged as it proceeded. Emergent design follows from the naturalistic assumption that individuals construct their own realities and an inquirer is unlikely to know enough about the constructed realities of others to be able to design a study a priori. The inquirers task is to make sense of multiple realities. The unstructured naturalistic methodology provides the inquirer the opportunity to explore diverse and complex realities without the limitations of a predetermined research design.

The conclusions of this study are traceable back to the data sources from which they were drawn. Some of this data is included as Appendices A, B and C. The data in the appendices provides to the reader with the opportunity to critically consider the methodology and conclusions of this study.

Naturalistic inquiry, like experimental research, is considered to be disciplined inquiry. The means used to provide rigor in naturalistic inquiry are, however, quite different than the means used in experimental research. In naturalistic inquiry rigor is supplied through such means as prolonged engagement in the study, verifying interview notes with respondents, keeping a methodological journal, and leaving an audit trail which allows the conclusions of the study to be traced back to their sources in the data. In this study interview notes were given to respondents for correction and verification, a journal was kept of my thoughts on the study, and the conclusions are traceable to the notes and documents collected during this study (these data sources have been organized and bound into a booklet which is approximately 200 pages long).

Description of the Study

In this section I present a description of the major events of this study. Exerpts from some of the documents discussed in this section can be found in the appendices.

The Initial Question

This inquiry began with my interest in finding out whether the principles of instructional development are being taught to teacher education students. In my original research proposal I explained my purpose in these words: "Training in instructional design, custom fitted to the needs of future teachers, would bypass the political resistance of older teachers and administrators. The next generation of teachers could bring more effective education through the front doors of the elementary and secondary schools. But how much instruction in the basic principles of instructional development are teachers-in-training receiving?"

Very early in the study the emphasis shifted from this original question to the problem of understanding the differences between the ways methods teachers and instructional development teachers think about teacher education. The primary reason for this shift was my discovery that the methods teachers I was interviewing appeared to think much more like instructional developers than I had previously imagined.

In-Depth Interviews with Two Methods Teachers

Data collecting began with two sets of interviews: three interviews with a science methods teacher and the three interviews with a math methods teacher. These respondents were chosen because of my interest in science and math education and because I was acquainted with these particular individuals. In introducing this study to these respondents I explained that my purpose was to find out what they thought was important in teacher education. (Exerpts from the notes of one initial interview are included in Appendix A.)

In the first of the three interviews I was interested in letting each respondent tell me, in an unstructured way, what he thought was important in teacher education, with particular emphasis on what was taught in his own methods course. Following these initial interviews I prepared summaries of what was said. In the remaining interviews (two with each respondent) I asked the respondents to elaborate, verify, and rank these important items. (One set of final rankings is given in Appendix A.)

As this phase of the study progressed I found that both methods teachers believed that systematically designed instruction is important, far more so than I had expected. Planning with objectives, formative evaluation, and the use of well-designed instructional materials were all ideas that were central in their courses. Learning to use technological devices to facilitate instruction, especially learning to use the computer, was also consistently mentioned as important.

I found the views of teacher educators on technology and systematically designed instruction to be curiously similiar to the views held by some instructional developers. I realized that my choice of respondents and the questions I had asked may have contributed to this finding. The next phase of the study was designed to further explore the differences in views between teacher educators and instructional designers.

Questionnaires Sent to Faculty Members

In the second phase of this study I sent questionnaires to seven methods teachers and seven instructional development teachers. In this brief questionnaire I asked faculty members two questions: what they thought teacher education students should learn about using technology in education and why they held the belief they did.

I received replies from three methods teachers and from four instructional development teachers. These written replies are provided in Appendix B.

Upon analyzing the data from these questionnaires I found that the variety of answers among groups was nearly as varied as the answers within groups. For example, in both groups there were members who defined technology as a process and other members who defined technology as a product. In both groups were members who were very positive about the processes of instructional technology and members who saw limitations to an education which is overly reliant on physical technologies. One methods teacher wrote that he could easily see the computer taking over the information providing role of the teacher while one instructional development teacher wrote that teaching is child-centered and not technology-centered. Based on my limited sample, it appeared that methods teachers were very positive about the role of technolgical devices (especially the computer) as a means to present and manage instruction; perhaps more so than instructional development teachers.

At the conclusion of this second phase I had three tentative conclusions, all of which suprised me: a) that methods teachers promote instructional development processes in their courses; that methods teachers promote the use of technological devices among their students; and that methods teachers are not adverse to the idea that some of the roles of the teacher could be taken over by electronic delivery systems.

I felt the need to share these tentative conclusions with faculty who were likely to dispute them. Accordingly, I arranged to individually interview a methods teacher (refered to in the appendices as Dr. E) who was known for his humanistic approach to teacher education, and an instructional development teacher (Dr. Z) known for his strong stance in favor of instructional technology in education.

Presenting the Findings for Critique

In the third and final phase of this study I presented these two respondents (Dr. E and Dr. Z) with my preliminary conclusions. (Exerpts from the interview summaries are given in Appendix C.)

Dr. E told me he was not suprised with any of my findings. He said that most teacher educators have a technocratic and utilitarian view of teaching that emphasizes techniques. Methods teachers are not themselves based in any intellectual tradition and do not attempt to make future teachers thoughtful about education. He said that he believes teachers are disenfranchised and deskilled as a consequence of not being allowed to develop their own instruction. Schools, with their increasing emphasis on pre-packaged instructional materials and testing, are aggrevating this problem.

Dr. Z had a very different view of my results. He believed that my conclusions were very much open to question. First, I could not be certain that methods teachers were really teaching instructional development concepts. Their understanding and use of these concepts may be very different than what I, as an instructional developer, would expect. Secondly, I had posed my questions about technology at such a high level of abstraction that the answers given by methods teachers only appeared to be similiar to those given by instructional developers. The real truth, he said, is that teacher educators are teaching teachers to be educational craftspeople under the mistaken assumption that teachers can be creative. Dr. Z believes that mediated adaptive instruction can take over many of the functions of the teacher. Technology can make use of specialization in educational planning and thereby could provide a much richer classroom environment than that currently provided by most teachers according to Dr. Z.

Conclusions

Four conclusions were reached about faculty views of instructional development. These four conclusions are tentative and apply only to some of the respondents who took part in this study.

Conclusion #1: Diversity of Views about Instructional Development

There is considerable variation in opinion about the value of systematically developed instruction among teacher educators. My preconceptions, perhaps due to my immersion in the culture of instructional design, were that teacher educators would not encourage the use of instructional design processes or products. This preconception was true in some cases. My final teacher educator respondent told me that there were some (a minority) teacher educators who believed that systematically developed instruction is very shallow education. The process of instructional development, according to this view, limits education to what is mechanical.

There are teacher educators, however, with a very different view of systematically designed instruction. All but one of the teacher educators in this study were positive about the products and processes of educational technology.

Conclusion #2: Unawareness of Diverse Views about Technology

The teacher educators and instructional development faculty who participated in this study were aware that there exists, within their own fields, a variety of views about the virtues of systematically designed instruction. These respondents were not aware, however, of the variety of views on this same topic within the other field.

Both of my final respondents (Dr. E and Dr. Z) discussed the controversy in their own fields concerning the strengths and weaknesses of systematically designed instruction. At the same time, they directly stated and implied (see Appendix C) that individuals in the other field were all of like mind.

My final instructional development respondent (Dr. Z) told me that his own views about technology in schools differ with the views Michael Streibel presented in a recent issue of ECTJ (1986). Streibel argues that systematically developed computer drill and practice, tutorials and simulations are harmful to learning. Dr. Z infered that teacher educators hold a similiar view (see Appendix C).

Yet this was not the only view about technology held by teacher educators. Most of the teacher educator respondents had a very pro-technology attitude towards instruction, even to the point of saying that the teacher may be replaced in part by the computer (see Appendix B).

Conclusion #3: Different Assumptions about Teacher Potential

At the root of the differences in belief about the place of systematically designed instruction are some fundamental questions about the abilities of teacher education students and teachers in general. My final instructional development respondent, Dr. Z, made it very clear that he thought teacher education students were of low quality and had little of the creativity that curriculum developers assume them to have. According to his position, this lack of ability and creativity is the primary reason that scientifically developed instructional materials are needed in the classroom. When I asked him if such materials would be necessary if teachers were able and creative he answered no.

My final teacher education respondent, Dr. E, had a different view of teacher potential. He felt that there were teachers with talent and that such talent needs to be used. In an article he showed me this respondent had written "While there are many teachers who want (and a few who need) to be told exactly how and want to teach, if thoughtful and creative teachers are not allowed to make meaningful instructional and curricular decisions then the result will almost certainly be a loss of pride in one's work" (reference not given to respect the respondent's anonymity).

These two respondents agree that not all teachers are capable of developing their own instruction. Dr. Z felt that the problem is acute enough to warrent restructuring education around materials produced by experts, giving the teacher a supporting role. Dr. E's view, however, was that teachers, given the right education, will be able to function effectively and autonomously in the classroom; autonomy being the foundation of quality teaching.

Conclusion #4: Placing the Blame for Educational Problems

I found it interesting that my final respondents, whose views about the place of technology in education were very different, both characterized the existing situation in the schools as negative and opposite to what they were proposing.

Dr. E, the methods teacher, characterized the current situation in the schools as disenfranchising and tightly controlled due to the mandated use of systematically developed materials. Dr. Z characterized teachers as poorly qualified but autonomous instructional decision makers.

Discussion

I believe that the conclusions of this study are related to some typical ways that individual human beings make sense out of their worlds. In this section I explain how the conclusions of this study can be understood in terms of some of the ways that misunderstandings and antagonisms arise as people interpret complex phenomena.

Awareness of Individual Viewpoints

First, individuals sometimes ignor the uniqueness of others, especially those who are perceived as belonging to an outside group. Based on the first two conclusions of this study, I would suggest that instructional developers are capable of forgetting that teacher educators, like all groups of people, are made up of individuals with diverse views on most issues. More communication with teacher educators would be my advice to instructional developers who wish to avoid the typical human tendency to develop inaccurate generalizations.

Awareness of Different Assumptions

A second tendency people have when making sense of their world is to forget that their assumptions may be different than those of others. At the root of the debate over the use of instructional development are differing assumptions about the match between teacher potential and the goals of education. One assumption that was identified in this study is that education is fundamentally an enterprise where information and skills are transmitted. Furthermore, teacher education students do not have the ability to serve as the central figures in such a process.

A contrasting assumption, also identified in this study, is that teacher education students do have the ability to serve as the central figures in any educational setting. According to this assumption, teachers must have a central role because education is essentially a human interaction.

Ignoring that others have different assumptions about the nature of education and the potential of teachers seems to have resulted in an antagonistic attitude among some instructional developers and some teacher educators. If instructional developers could step outside of their own assumptions about educational aims and teacher abilities they would be more likely to appreciate and assist those with other assumptions.

Placing the Blame

A third and final way people tend to make sense out of their world is to assume that if something is not working it must be someone else's fault. Some teacher educators partially blame the current education crisis on systematically designed instructional packages while some instructional development faculty blame the same crisis on teacher freedom to do whatever they want. A constructive response towards these contrasting beliefs might be for individuals to carefully consider what the other side has to say and be willing to incorporate them into their thinking

Some Final Thoughts

As with all naturalistic studies, the complexities and unique local features (as well as the assumptions of the research paradigm) make it impossible to generalize specific results, either to the faculty members in the school of education where this study took place or to any other faculty. However, the result that I hope this study will have is to provoke thought among those interested in working towards the building of better educational systems. With this in mind, I would like to share an insight I have gained from my participation in this study.

I can imagine that there are two opposing ways of thinking that influence the minds of both methods teachers and instructional developers: expansive thinking and disciplinary thinking. Expansive thinking is creative, unfocused, innovative, idealistic, irresponsible, and humanistic. Disciplinary thinking is systematic, dehumanizing; objectives-based, sterile, and utilitarian. Individual educators tend to be influenced more strongly by one or the other of these ways of thinking and tend to see less value in the ideas of those influenced by the opposing way of thinking. My hunch is that good instructional design and practice flourish when these two ways of thinking are fully appreciated and balanced.

Inquiry aimed at making sense of how individuals think about instructional design and education can play a significant part in communicating ideas between and among instruction developers and others in the educational community. Such inquiry, if done and received in a spirit of openness and fairness, could have widespread benefits.

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Appendix A: Selected Data from the First Stage of the Study

Interview With Dr. B.

I saw Dr. B. in the hall outside his office as I arrived for our first meeting. He offered me a cup of coffee, and got himself a cup. He told me that his wife would be bringing him his breakfast at about 8:20.

I explained the consent form to him and he signed it without question, then I briefly explained the research I was doing. I told him that I wanted to get some idea of what he thought teachers should be taught. He told me first that you can't teach teachers how to teach; in fact you can't teach anybody anything. A person has to learn how to teach (or do anything). He said that he provides tools with which to think about teaching. It is through thinking that teaching can improve. If teachers don't think, nothing will improve. He said that poor teaching is an easy job.

He teaches a five unit methods class including lecture, theory and laboratory. Students have different kinds of laboratory experience, they can hide behind the aparatus at first but increasingly move towards interactive teaching.

He is a cognitive science individual. It is most important to find out what students know and add to that. He interview students, talks to them, listens to them and then provides activities that will provide the next challenge. He added that he is not sure that this is successful.

Every year he changes the course. Trying to get at something he missed before. Now, in his later career, he finds most assignments are average to above average-they meet the needs of the students. Students need to feel that the course meets their needs, that it is worthwhile. They need enthusiasm.

He described some details about his course:

- Students identify a chapter and identify all concepts in a manner consistent with Gagne. They then make a chart showing how the chapter treated the topic. Students make a network diagram in another assignment. Students also write performance objectives and intended learning outcomes.
- He is concerned that students find objectives for each category of outcome, not just the typical cognitive outcomes. He is concerned that objectives are mechanically correct and that the behavior is significant. Students can redo assignments if they are turned in on time and many do (the best teachers are often those who turned in an assignment again for a point). The objective of the

course is to become a profesional not learn content: they need to get better.
People have to realize that they do not need to do it right the first time.
- Lesson plans should have 'mind captures', and deal with the past(what students already know), present(what is important) and future.
- He believes in formative testing: test early and often (he compared this to Mayor Daley's quote: vote early and often). He believes that students must create a resource list. Look for the full variety of resources. Variety is a powerful variable in learning. It takes 5 years to become a good teacher perhaps because it takes 5 years to locate all the materials.
- Communication is the most important process skill. Science begins and ends with a hypothesis (not observation).
- His students are encouraged to implement with existing materials, not reinvent the wheel, which is what most beginning teachers tend to do. To do a good job you have to be a good thief.

2. Summary of Dr. B's Views on What is Important

Introduction: The following information is derived from a series of three interviews. The first was open ended and resulted in a list of items that are important in the teaching of a secondary science methods course. The second and third interviews were used to clarify, confirm and extend this list of items.

The focal question of this study became : 'What is important in teaching a secondary science methods course?' The list of important items is given below. These items are organized into categories and subcategories to assist the reader.

ITEMS ARE LISTED BELOW ALONG WITH A REASON [IN BRACKETS] THAT EACH ITEM IS IMPORTANT. Following most of the items is a number (1,2 or 3) which indicates the relative importance of that item and a letter (A, B or C) which indicates the relative success the course has at achieving that item. (The respondent noted that the relative success of an item is related to when the item is presented during the semester: those items presented later tend to be more successful because more prerequisite learning has gone on.)

Category 1: IT IS IMPORTANT THAT THE METHODS TEACHERS REMEMBER THESE IDEAS

1. Provide tools with which to think about teaching[you cannot teach anyone anything, they have to do the learning themselves] {3/B}
2. Frequent evaluation[provides the optimal amount of uncertainty: positive tension] {2/A}
3. Students should realize it is possible for everyone to get full credit for an assignment[so they can pass this attitude to their own students] {2/B or C}
4. The role of the critic teacher is important [this teacher has a lot of credibility] {2}
5. Schools need to reform [teachers need more authority and responsibility] {3/B}
6. Model appropriate teaching behavior[there is no credibility in the attitude: Don't do as I do, do as I say] {2/B}
7. Students should be taught that which they perceive will be useful [for teacher credibility] {1/B}

Category 2: IMPORTANT GUIDING PRINCIPLES FOR TEACHERS

Subcategory 2.1 GENERAL PRINCIPLES
8. Find out what students already know and build on that[cognitive science has pointed this out as an effective strategy] {3/B+}
9. Project the message that students can and will learn[this is a self-fullfilling prophesy] {3/A-}
10. Know the characteristics of future pupils [think of them as being not future science teachers but in the great variety of roles they will play] {3/B}
11. Maximize student-student, student-teacher interaction[learning is an active process] {3/B-}
12. Realize that students do not have to do things right the first time [we need to practice] {3/B}
13. Find relations between concepts(networking)[relationships are the glue that hold ideas together] {3/A-}

Subcategory 2.2 SCIENCE PRINCIPLES (THESE SHOULD BE THE RESPONSIBILITY OF ARTS ANDSCIENCE, NOT TEACHER EDUCATION)
14. Realize science is not what is in a science textbook, that science has wrong paths, frustrating moments ... it is not all neat and clean [they have often missed this despite being science majors] {3/B}
15. Do scientific thinking, which is making hypotheses based on information {3/B}

16. Teach the understanding of relationships[it important to know how and why you know things] {2/B}

Category 3: PREPARING TEACHERS FOR THE CLASSROOM IS IMPORTANT

Subcategory 3.1: GENERAL PREPARTION
17. Identify resources[variety is a powerful variable in learning] {3/B}
18. Be aware of science education issues[for job interviews, communication with colleagues] 2/B}
19. Learn to use the material in the AV learning laboratory[teacing aids can be a great help in saving time and allowing more teacher contact with the class; technologies need to be used properly] {3/B}
20. Teach using the strategy of 'hands on, minds on'[learning is an active process] {2/B+}
21. Understand different categories of intended learning outcomes[to avoid a myopic view of learning] {2/B}
22. Identify concepts[concepts are good handles, they are more generalizable than facts] {2/A-}
23. Ask productive questions(those which students can answer)[because bad questions are common and serve no purpose] {3/B+}

Subcategory 3.2: LESSON PLANS
24. Prepare lesson plans[otherwise variety is not possible] {2/A-}
25. Find objectives for many different cognitive outcomes[otherwise only one type tends to be taught: knowing facts {2/A-}
26. Prepare a case history lesson plan(dry lab)[variety] {2/A-}
27. Prepare a laboratory lesson plan[this is difficult to implement properly] {2/A-}
28. Write performance objectives or a table of specifications with significant behaviors[so the objectives are not formal but useful] {2/A}
29. Design mind captures for lessons[to get the students attention] {2/B}
30. Put question sequences in lesson plans[this defines the path of the lesson, it is the operational definition of the objectives. {1/A-}
31. Classify questions according to the type of outcome[to insure a variety of question types] {2/A}

Subcategory 3.3: PRESENTATION
32. Be able to communicate[writing and talking prove that you know something and give you practice thinking] {3/B+}
33. Get students to pose questions at the right time, not before the interest is there[otherwise learning is highly perishable] {3/B}
34. Receive feedback on presentations[so they can work on weaknesses] {3/B}
35. Making oral presentations[for practice]{2}
36. Videotaping oral presentations[for feedback] {2/B+}
Subcategory 3.4: EVALUATION
37. Know how to do formative evaluation[provides corrective feedback] {3/A}
38. Know how to write a formative test[the philosophy implicit in formative testing is important: what is it that students still need to learn? vs. what do students not know?] {3/B}
39. Evaluate software[so they know what is valuable] {2/A-}
40. Evaluate textbooks[so they know what to expect from a textbook] {2/B}

Appendix B: Selected Data from the Second Stage of the Study

1. Responses of Instructional Development Teachers
Question 1: What are the most important things teacher education students should learn about using technology in education?
Question 2: Why do you believe this?

Dr. Z
1. Learn to retain(and make the best use of)the integrity of technologically-based instruction instead of second-guessing decisions that have already been used. Don't cannibalize instructional packages.
2. The vast majority of teachers have a king-of-the-hill attitude when most of them haven't risen above the peasant level. They need to accept technologically-based instruction on at least an equal footing with their own.

Dr. Y
1. a) They should understand technology as a process i.e. ASSURE model. b)They should know the characteristics of various media and how they fit into the process.
2. Using a procedural model (such as ASSURE) can increase the effectiveness or th eteaching learning process and that is an important objective of education.

Dr. X
1. When the findings and principles of the behavioral sciences (psychology, anthropology, linguistics, artificial intelligence, etc.) are applied to the
analysis and solution of the problems of instruction, resulting in ever more effective teaching, we have instructional technology. Teachers need to know how to design, develop, deliver, and evaluate instruction. But no one person can do all this. We will have to specialize.
2. A purely intellectual exercise growing out of the definition of technology (and instruction) combined with what little I know about the sciences that could lead to an applied educational art: instructional technology.

Dr. W
1. a. Soft technology: The concepts of instructional design in general. The process of instructional development at the classroom level.
b. Hard Technology: Use of chalkboard, bulletin board, overhead, film projector, VCR, using computers

2. My position clearly is that teaching be objectives-centered/child-centered and not technology-centered. In technology use I like teachers to learn to use the chalkboard as well as the computer.

2. Responses of Teacher Educators

Question 1: What are the most important things teacher education students should learn about using technology in education?
Question 2: Why do you believe this?

Dr. B. (a science methods teacher)
1. Students should learn that technology can often deliver and collect information faster and more efficiently than can humans.
2. Whenever the computer is faster and more efficient it should be used to assist in instruction. I do not see computers replacing teachers in my lifetime, however they could replace the information providing role of teachers very easily.

Dr. C (an art methods teacher)
1. a. Be prepared to build instructional data bases(usually verbal)-get ready for when they become available from some centralized source.
b. Word processing/E-mail/spreadsheet tools are essential
c. Some preliminary programming-to understand the process of machine operation first hand (graphics are very good for this)
d. Experience with various interactive devices/programs: educational applications must feature interactivity and individualization
2a. Involvement with a course on computers for teachers since its inception
b. Involvement with simulated databases for 16 years and retrieval for educational applications
c. Reading literature of computer based education
d. Teaching computer graphics to teachers
e. Continuous use of my own computer

Dr. D (a reading methods teacher)
1 a. What areas technology may be useful. i.e. management, instruction, etc.
b. How technology may enhance learning for students.

2. In order to make the most use of technology it is important to know the specific areas where it (technology) has the greatest potential. Secondly, we should base all our technology in terms of how it will improve or enhance student learning. We need to keep focused on what its use does and not on what it looks like.

Appendix C: Selected Data From the Third Stage of the Study

Interview With Dr. E , His Office, 9:30 - 10:30
I started by telling Dr. E about my research: characterizing it as a study of how methods teachers and ID teachers view teacher education. I then gave Dr. E my three tentative conclusions and asked him to comment on them.

Conclusion 1: There is little difference between how each group promotes instructional design tools like objectives and evaluation.

Dr. E said that did not suprise him: that methods teachers have had and do have a technocratic view of teacing. They are utilitarian and emphasize techniques.
He does not hold this view. He believes that the goal of . teacher education should be to make teachers more reflective about the teaching process.(see Dewey on the Relation of Theory to Practice, circa 1904) Knowledge should be presented as problematic, not absolute. This is not to say that objectives should not be taught: but they should be explored, discovering the trade-offs. It is important to deal with issues such as social injustices. A safe environment must be provided for teachers.

Conclusion 2: Methods teachers are, if anything, more positive about the role of physical technologies, such as the computer, improving the status of education.

Dr. E said that this was not suprising because methods teachers have little historical perspective. As Dewey said, they are suseptible to fads because they do not see themselves as a body of intellectuals. They believe that technologies would do more of what we do now only better. In essence computers are being put to limited use: mainly to do workbook type things. Teachers are being treated as mindless individuals. In some upper class schools there may be an attempt to see technology used creatively. In other schools we will see only glorified workbooks.

Conclusion 3: Teacher educators are willing to consider the notion that the information presenting role of the teacher can be taken over by mediated instruction.

Dr. E said that teachers are seen primarily as managers who are not supposed to be thoughtful. The conception of learning varies. Some believe that children bring something to the learning situation.

The perspective of the society is restricted as are the views of most teacher educators. Dr. E believes that teachers are being disenfranchised and deskilled by not being allowed develop their own instruction.. Now, teaching function is largely managerial and is being moved more that way. The programs being developed are often based on narrow methods, and assume that there is someone who can do it better. In this view it is asumed that we need to be more specialized and that kids are similiar to each other. This is elitist and belies common sense. It makes people who design programs feel good about themselves. But they see education as if it were like putting lots of bumper stickers on a car.

December 18 Interview With Dr. Z, His Office 10:30-11:15

I introduced my study and then asked Dr. Z to comment on the three conclusions I had reached.

1. Both teacher educators and IST professors promote instructional development tools such as objectives and formative evaluation.

Dr. Z made the point that the tools such as evaluation and objectives can mean very different things to different groups. Evaluation is usually not used as a way of improving products by teachers, although the best of them will use it as a means of improving their own performance.

Objectives too can mean diferent things. Is the final exam based on the objectives? In short, we must always be skeptical of postures.

Conclusion 2: Teacher educators are positive about using physical technologies, in fact, perhaps more positive than ID professors.

One way that an undergraduate media course was eliminated was by having this incorported into methods courses. This would tend to make media teaching more ancillary. Teacher educators are in the business of teaching teachers to be king of the hill and we are part of the hill. You also have to be careful about what people say; if you ask people in media centers if they use instructiona development they will say yes.

Dr. Z said that if questions are posed at a sufficiently high level of abstraction you can get agreement.

Conclusion 3: Teacher educators are willing to consider the notion that the information presenting role of the teacher can be taken over by mediated instruction.

Teachers educators kid themselves about the value of the products they turn out. They are scraping the bottom of the barrel. There are indications that teachers like good materials that have been prepared for themselves but that curriculum developers keep pushing the notion that teachers need to be creative. They keep spinning out the notion that teachers have expertise and provide them with more strategies than they could ever use. Teachers are really looking for all the help they can get. The real reason for teacher burnout is the strain and stress caused by having to do so much.

It is so difficult to make use of what we are learning about designing materials: Gagne's and Merrill's ideas are not applicable by teachers who do not have the time or ability to learn them.

It is possible to teach problem solving and other kinds of thinking using mediated instruction in the form of adaptive instruction. Jerome Bruner said that when he wrote his book that he wanted to provide material that teachers were not up on and to model the discovery and problem solving type learning that teachers were not using.

Dr. Z said that he could not imagine a more stimulus poor environment than being in a classroom with a single, poor teacher. Technology can make use of specialization of knowledge, is more reliable, can spread the expertise of the few expert teachers that we have.

Title:

Training Children to Use Learning Strategies to Improve Their Ability to Attain Concepts

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TRAINING CHILDREN TO USE LEARNING STRATEGIES TO IMPROVE THEIR ABILITY TO ATTAIN CONCEPTS

By

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Training Children to Use Learning Strategies to Improve Their Ability to Attain Concepts

By

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Paper presented at the 1988 Annual Convention of the Association for Educational Communication and Technology, New Orleans, LA.

Interest in learning strategies stems from a real concern for the academic performance of students. Whether the cause is poor teaching methods, inadequate curricula, or their own indifference, students are failing to succeed in the classroom, and the problem is widespread and severe. The Nation At Risk (NAR) and the National Assessment of Educational Progress presented discouraging news to educators. The reported results revealed that some 23 million American adults are functionally illiterate, 20 percent of high school students cannot read with literal comprehension and 31 percent cannot write letters. In addition, the studies showed a steady decline in the overall performance in high order thinking skills over the last two decades. Students were, on the whole, unable to read, write or comprehend at standards established more than twenty-five years ago (The National Commission on Excellence in Education, 1983; Task Force on Education of Economic Growth, 1983).

Based on the findings, Paul Copperman concluded that:

"for the first time in the history of our country, the educational skills of one generation will not surpass, will not equal, will not even approach, those of their parents" (p.11).

Other contributors to the Nation At Risk study concluded that "the educational foundations of our society are being eroded by a rising tide of mediocrity that threatens our very future as a nation and a people" (p.5).

The Demand for Reform

To stem the "tide of mediocrity" and stop "the erosion of the educational foundations," the NAR Commission recommended such reforms as more rigor in the curriculum, higher standards of performance and expectations, lengthening the school day and year, and making more effective use of time during the school day.

The NAR Commission further claimed that these reforms could be largely accomplished through the children's own efforts. This suggests that it is up to the student to perform to his or her utmost ability in order to succeed in the new, more rigorus, classroom. Yet at the same time, this increased effort is being asked of the very same children who are at an all time low in school achievement.

Leaving it up to students to adapt to the more rigorus classroom is more likely to lead to failure than success. B.F. Jones (1986) argues that the demand for rigor without an accompanying emphasis on improving the quality of instruction will increase the number of failures at all levels of schooling" (p.6). Resnick (1984) also voices concern that the calls for reform may lead to a widening of the gap between high and low achievers. Efforts must be made to develop quality instructional programs for both high- and low- achieving students. Without proper guidance, it is doubtful that students will succeed in this endeavor (Jones, 1986).

The success or failure of students in the learning process may also depend on their own skills in activating learning strategies relevant to the instructional task. It has been found that effective learners spontaneously generate and use specific strategies when interacting with the instructional materials (Anderson, 1980a; Herber, 1978). In contrast, novices and low achieving students do not generate strategies spontaneously (Rohwer, 1980). The ability to assimilate these strategies and apply them to a variety of instructional tasks may improve students' performance in the classroom.

While educators often assume that students know how to approach and optimally manage their own learning, this may not be the case. In reality children need to be taught to learn and to use new information and skills efficiently. One possible way of meeting this need is to provide explicit instruction in the use of learning strategies that help children in their acquisition of new concepts.

Background of the Study

Learning Strategies

Learning strategies are those self-generated methods that students use to process information for later retrieval. Common strategies include mnemonics, rehearsing, paraphrasing, imagery (Weinstein, 1979; Pressley, 1984; Brown, 1980; Rigney & Munro, 1981). Recent research, however, suggests that not all students generate or use appropriate strategies, but instead tend to rely upon those which are familiar or easy to use (Weinstein, 1978, 1981; Brown & Smiley, 1978; Rigney, 1978; Rohwer, 1980; Battig, 1979).

Battig (1979) states that there is wide variation in students' abilities to generate and use strategies. Shuell (1980) suggests that an individual's learning strategies, once aqcuired, are relatively constant and stable. Once a particular strategy is learned, it then can become a stable factor within the learner for his or her own use.

Training of Learning Strategies

The purpose of providing instruction on learning strategies is to make specific strategies and methods available to individuals (Weinstein & Mayer, 1985). Furthermore, Rigney (1980) maintains that the purpose of training is to insure that such strategies facilitate rather than interfere with learing, and that they displace the less efficient strategies already in use.

In order to assist learners in achieving those purposes, researchers have begun to investigate ways to train learners to use strategies. To date, research has explored the explicitness of training procedures. However, while there are some common training procedures, they may vary according to the design of the training program and whether strategies are taught singly or in combination.

Explicitness is the type and quantity of directions on strategy use provided within the training. For example, Weinstein and associates (Weinstein, Cubberly, Wicker, Underwood, Roney, & Duty, 1981) reported several studies which investigated the effect of two versions of training over no strategy training. Two types of instruction occurred, informed and explicit. Informed training described the learning strategy and advocated its use while the explicit training included direct instruction on strategy use, examples with practice, and corrective feedback. The results significantly showed that explicit instruction was more effective than the informed version and that both were more effective in improving posttest performance than no training at all.

Brown, Campione and Day (1981) also investigated three variations of explicitness: 1) in *blind training*, students were told to use a strategy; 2) in *informed training*, students were told to use a strategy and how it would help their learning; and 3) in *self-controlled training*, students were shown how to use the strategy as well as how to monitor and evaluate their strategy use. They were also told how the strategy would help their learning. The report suggests that the more explicit the training was the more powerful its effect on performance.

Dansereau (1985) also considers modeling (the demonstration of strategy use) in conjunction with feedback on learner output as important components of training. Further, Babbs and Moe (1983) reported that explicit instruction, which included specific directions, demonstrations of strategy use, and planned practice is beneficial to the young. Burger, Blackburn, Holmes, and Zetlin (1978) found similar results in a study using young children. Those subjects who were trained to actively sort and cluster pictures had significantly improved recall over those who did not. Other researchers have found similar results (Pressley, 1984; Butterfield & Belmont, 1977; Canelos & Taylor, 1981).

The research on learning strategy training suggests several components as necessary for effective teaching of strategies. These are as follows:

1. Demonstrating correct strategy usage.
2. Providing an explanation of its utility in learning a task.
3. Planning for active participation and practice by the student.
4. Providing for feedback on performance.

Overall, findings from these studies suggest that explicit training in strategy usage is more powerful than simply telling students to use a strategy. However, both types of instruction tended to produce better performance than no strategy instruction at all.

While it appears that students can be trained to use strategies, the generalization or transfer effects have yet to be found in the literature (Canelos, 1979; Brown, 1981; Weinstein, et al., 1978, 1979; Dansereau, 1978). Lawson (1980) states that while the promise of benefits from training appear obvious, those realized thus far have been disappointing. This may be due to other influencing factors within the instructional environment.

Learning Strategies and Individual Differences

The application of stratgies may be affected by individual differences among learners. To date, most studies that assess strategy training have not looked at the interaction with individual differences (Dansereau, 1985, p. 215). While there is potential for many types of individual differences, such as level of motivation, task persistence, or locus of control, to affect learning strategy usage, it may be reasonable to begin with the two learner characteristics which are most extensively researched. Age and general ability may be the learner characteristics that interact with the teaching of the learning strategies.

In general, younger students use strategies less effectively than older students (Brown & Smiley, 1978; Kail, 1979). Research has shown that children can be trained as early as fourth grade to use strategies in an instructional task; however, they do not use strategies to the fullest extent (Babbs & Moe, 1983; Burger et al, 1978; Reinking, 1983). This may be due to the level of cognitive development; prior to age eleven, children are not mentally ready to engage in effective strategy use. The mental development of an individual increases with age and levels off at adulthood (Kail, 1979).

Research investigating general ability as a factor showed that mentally handicapped subjects could be trained successfully to use a strategy. Despite an increase in learning performance, however, transfer from one task to another did not occur (Brown, Campione & Day, 1981). Students in a normal ability range outperformed mentally handicapped children of the same age (Burger, et al., 1978). Rohwer (1981) has shown that higher ability students have a greater capacity for generating strategies than those of lesser ability. More research is needed on the effects of providing training in learning strategies to students of differing intelligence levels.

Learning Strategies and the Instructional Outcomes

The type of instructional outcome may also affect the training in and transfer of learning strategies. Much of the research on learning strategies has focused on verbal information outcomes; that is, instruction that is concerned with memorizing a number sequence or a vocabulary word list, or sorting pictures (Canelos & Taylor, 1981; Weinstien, 1978; Burger, et al, 1978; Pressley, 1983). According to Gagne's hierarchy of instructional tasks, verbal information is at the lowest level of learning outcomes.

At the highest level is problem solving, or in Gagne's terms higher order rules. Problem solving requires learners to combine rules in some unique manner to arrive at the unique solution (Dick & Carey, 1985). Research investigating problem solving strategies may be associated with such techniques as brainstorming, Socratic method, means-end analysis, and incubation (Anderson, 1980b; Rummelhart & Norman, 1981).

However, a more central component of school learning is concept acquisition. Gagne states that the majority of information learned in school is comprised of concepts. Of particular interest to this investigation, are strategies that can be linked to concept acquisition tasks. Very little has been reported about learning strategies in conjunction with concept attainment.

Early studies by Rosco and associates investigated use of mental imagery in concept attainment with significant results (Rosco, Tennyson, & Boutwell, 1973; 1975). Carrier, Joseph, Krey and LaCroix (1983) found that sixth grade students who were instructed to generate their own images performed significantly better on a concept attainment task than did those who were supplied with visuals. There was no verification other than test performance to indicate whether students used the strategy.

Using twelfth grade subjects, Park (1984) found that instructing students to compare examples was more effective on posttest performance than having them concentrate on attribute identification. However, the study did not investigate whether or not students would generate images on their own without directions to do so.

Finally Allen (1982) using a concept task, also asked subjects to create their own examples which were to be similar to and distinct from the concept prototype. While the results of his dissertation study did not reach statistically significant levels, there was a trend toward improved performance for those subjects who generated their own examples over those who were assigned examples.

In studies involving concept acquisition tasks, there is some indication that having students manipulate examples leads to improved test performance. However, these studies were conducted with little or no explicit training in strategy use.

Purpose of the Study

The primary purpose of this study was to investigate the potential individual and combinatorial effects of learning strategy training, and ability on children's acquisition of new concepts. A second purpose was to determine if use of the strategy, generation of examples, would transfer to new concept lessons once the training had been completed. In an effort to relate the literature review to the study, the hypotheses, research questions, and related implications are presented below.

Hypothesis One

There would be a main effect for training. Subjects with explicit training would have significantly higher posttest scores for lessons than those in either the informed or no training treatments.

Research Question. Which type of learning strategy training is most effective for use with concept acquisition?

Reported results indicate that not all students use learning strategies appropriately, and that they need to be taught to learn and use learning strategies effectively. Klausmeier (1985) and Tennyson and Cocchiarella (1986) advocate the development of a strategy for assisting learners in their concept acquisition be included in the instructional design. However, there is a paucity of empirical research on such training and use as it relates specifically to concept acquisition.

It has been found that strategy training which provides explicit directions, a demonstration of strategy use, and provisions for practice with feedback should result in improved test performance of various instructional tasks. It is reasonable to assume that such training would lead to improved performance on concept attainment tasks.

Hypothesis Two

There would be a main effect for ability. Subjects of higher ability would have significantly higher posttest scores than those of lesser ability.

Research Question. How does ability affect performance and the use of learning strategies?

In general, it has been found that students of higher ability are more capable of engaging effectively in instructional tasks and attain higher performance scores than lesser ability students. It has also been reported that the higher ability learners are able to generate and use strategies effectively when interacting with instructional materials while lower ability students do not. Because ability is a relatively stable trait among learners, it is likely that similar results would occur in this investigation.

Hypothesis Three

There would be an ordinal interaction between treatment and ability. The lesser ability subjects receiving the training would outperform those of the same ability level who received either the informed or no training treatment. However, higher ability subjects in the three treatment groups would do comparably well on posttests.

Research Question. How does ability interact with differing levels of instruction in learning strategy use?

Dansereau (1985) states that most studies examining methods of strategy training have not investigated the interaction of training and individual differences. To extend the research, this investigation studied the interactive effects of differing levels of ability within the normal range of intelligence and strategy training and use.

Drawing upon the research related to ability by treatment interactions (ATI), it has been found that low ability students are assisted by explicit instruction more than higher ability ones. In addition ATI research suggests that simple instructional support often is useless or even detrimental to high ability students (Snow & Peterson, 1981; Cronbach & Snow, 1981). This study was designed to investigate whether the selected strategy training methods would assist lesser ability students without hindering higher ability students.

Hypothesis Four

Those subjects who received explicit training will outperform subjects in the other treatments in the concept lessons in the transfer sessions.

Research Question. Will learning strategy use transfer to new situations after training?

Findings suggest that transfer is promoted by trying to provide some common elements of the initial situation within the new situations. Transfer is also enhanced by identifying the utility of strategy use to the new situation (Clark & Voogel, 1985; Cronbach, 1977). Derry and Murphy (1986) advocate using an unobtrusive prompt within the instruction to assist transfer to new situations.

Methodology

Sample

Subjects were drawn from an initial pool of 178 sixth grade students in two middle schools in the upper midwest. There were 102 boys and 76 girls. They were approximately twelve years old at the time the study was conducted.

Treatments

The differences in the three treatment conditions were based on the amount of training subjects received for the learning strategy, self-generation of examples. The explicit training (ET) subjects were taught to generate their own examples. The training consisted of experimenter modeling, student practice, and corrective feedback on the students' own verbal and visual examples of the concept that were drawn on scratch paper.

The informed directions (ID) treatment were merely directed students to make up their examples of the concepts taught. They were told that they could use the scratch paper to write or draw their examples. However, no modeling, practice, or feedback was provided.

The *no training (NT)* treatment group did not receive training in or information on strategy use. For consistency, they also received the scratch paper, but told to use it if they needed to do so. They read the content narratives and completed the activity.

Treatment materials

Five concept lessons were developed as the instructional materials. The five topical areas taught were prepositional phrases, clouds, propaganda techniques, context clues, and mollusk shells. With the exception of the lesson on prepositional phrases, all were coordinate concept lessons. A coordinate concept lesson is one that contains a superordinate concept and two or more subordinate concepts. While these subcategories share common critical attributes of the main classification, they also have distinct characteristics of their own. They were designed according to the procedures prescribed by Tennyson and Cocchiarella (1986) and Merrill and Tennyson (1977). They were self-paced, self-instructional materials in a written format.

Content narratives were provided for the NT treatment group during the first three sessions. These brief passages were the placebo lessons on the topics of prepositional phrases, clouds, and propaganda techniques. The reading of the content narrative and completion of a short exercise were used as means of controlling for the time.

Instruments

Several instruments were used to measure the various independent and dependent variables. Ability was measured by the Cognitive Skills Index of the national standardized test, the Tests of Cognitive Skills (CTB-McGraw, 1982).

Concept achievement was assessed by a total of nine posttests. There were three lesson posttests, two immediate posttests, two delayed posttests, and two retention tests. They employed a multiple choice, paper and pencil format.

Scratch paper was provided as a means to determine whether a learning strategy was used in the experiment. An opinion survey was a supplemental measure used to obtain student perceptions of the lessons, their effort, and their strategy use.

Procedures

A pilot test of the materials and procedures was conducted. Based on the results, one lesson was deemed unsuitable content for the age level and thus replaced. The remaining lessons were corrected for typographical and spelling errors. The time allotted for the lesson was increased to about an hour. While ambivalent at best, the results warranted further investigation of learning strategy use but with a larger sample size.

Subjects within each classroom were randomly assigned to the three treatment conditions. One week before the experiment was to begin, the experimenter visited each classroom to make introductions, explain the procedures, and address any questions that students had regarding the study. At that time, subjects were told that their participation would not affect their school grades and that all information would be kept confidential and anonymous. A list of students assigned to the three treatments was given to each classroom teacher so that students would be ready for the first session the following week.

The study consisted of two parts: training sessions and transfer sessions. The sessions occurred over a period of six weeks towards the end of the school year. A chart demonstrating the sequence of the instructional presentation is shown in Figure 1.01. There were three one-hour lessons in the first part of the study, the training sessions. At that time, the ET and the ID treatment groups were explicitly trained or informed on the strategy (described previously). The lessons were immediately followed by a lesson posttest. At the same time, the NT treatment group remained with the classroom teacher and received the content narratives; they did not receive a lesson posttest. Prior to conducting each session, experimenters and classroom teachers received written directions.

Figure 1.01 about here.

The transfer sessions were the last half of the study. They were designed to test and compare the effects of transfer of the learning strategy training for the two experimental treatments against the NT treatment group. Subjects from all three treatments were grouped together in the classroom for two sessions of approximately one hour in length. They received the same directions, instructional materials, and tests. A final session of approximately one-half hour was conducted to administer the delayed posttests, retention tests, and the opinion survey. A third experimenter delivered the directions during these sessions to control for any potential experimenter bias.

Design

The study employed a one-way factorial design with three treatment conditions. The dependent variables were analyzed using a multivariate analysis of covariance. A repeated measures design was employed on the three training session tests and the six transfer session tests. The covariate, ability, was assessed by the composite scores on a test of mental ability.

Data Analyses

A multivariate analysis of covariance (MANCOVA) was conducted on the scores from the immediate posttests administered to the two experimental groups during the training sessions. MANCOVAs also were conducted on the performance scores for the immediate and delayed posttests and the retention tests of the lessons in the transfer sessions. Univariate ANCOVAs were run for those main effects or interactions which reached significance. A cross tabulation was completed on the secondary dependent measures, the scratch paper, and the opinion survey items as a means for comparison with test performance and evidence of strategy use.

Data analyses were conducted to yield reliability estimates on the posttests, descriptive statistics on the ability of the subjects and performance measures, and tests of the formal hypotheses.

Results

Reliability

Satisfactory but moderate reliability estimates were found on each of the immediate, delayed and retention posttests. Item analyses on an immediate posttest indicated that some items did not discriminate well; the rest were considered good discriminators. Because of the poor items, the reliability of the tests was probably lessened.

Descriptive Statistics

The mean of the lesson posttest scores and the standard deviations were similar for all groups. Table 1.01 shows the scores for the ET and ID treatment groups for the three lessons during the training sessions. Mastery of the concepts was at about fifty percent.

Table 1.01 about here.

Table 1.02 shows the scores for all three treatments for the Context Clues lesson given during the transfer session. Again the mean posttest scores and the standard deviations were not significantly different from each other. It is interesting to note that the NT group means was higher than the other two groups.

Similar results can be seen in the scores for the Molluck Shells lesson in Table 1.03. Again there were no statistically significant differences among treatments.

Tables 1.02 & 1.03 about here.

Pearson Product-Moment Correlation

Correlations showed that ability correlated with the tests. Also Table 1.04 shows that the nine posttests correlated with each other in general.

Table 1.04 about here.

Formal Test of Hypotheses

Two statistical assumptions were tested before each of the MANCOVAs was conducted. First, the Bartlett-Box M test for homogeneity of variance/covariance matrices and, second, a test of homogeneity on the regression slope for CSI ability across cells were conducted. These revealed no significant difference and also meant that there was no aptitude by treatment interaction as hypothesized.

A third preliminary test for order effect on the performance measures of the transfer sessions was conducted. Because each of the sets of performance measures was given to half the subjects in a different sequence, a test for order effect had to be conducted before the data could be pooled. It was not significant, Wilk's lambda .98 and *F* (4, 151) = .85, *p* = .50. Thus the various performance measures could be combined for the statistical analyses.

The following are the findings of this investigation. While there the NT posttest scores were slightly higher than the

ID scores in the training sessions, there was no statistically significant difference among treatment condition posttest scores.

The ET treatment used the learning strategy in the training session, but showed a significant drop in strategy use during the transfer sessions. The use of the learning strategy was minimal by the ID treatment group and almost nonexistent by the NT group; this usage was consistent in both the training and transfer session. Thus it is not surprising that strategy training had no significant effect on performance of the transfer session posttests.

Ability was found to correlate significantly with performance (See Table 1.05). However, there was no significant difference in strategy use between high and low ability students.

Table 1.05 about here.

The opinion survey indicated a variety of student preferences for lessons. There also was a variety of opinions as to which lesson was most difficult. The majority of students placed themselves in the top two rankings of work effort, "did their best" or "good job." The subjects also seemed to accurately report their use, or more appropriately, their lack of use, of the learning strategy. This was confirmed by a comparison with the actual scratch paper on which they generated their example.

Discussion and Conclusions

It is not, of course, surprising to discover that in both the training and transfer sessions, higher ability students performed significantly better on posttests than lower ability students. The literature on ability is replete with research findings suggesting that, in general, higher ability students will outperform lower ability students (Snow & Peterson, 1985; Cronbach & Snow, 1977). This study is in agreement with that general conclusion. The remaining hypotheses of the investigation were not supported. Although the general lack of significant results precludes drawing definitive conclusions, some tenative ones are warranted based on the findings of this study.

Training in Learning Strategy Use

Research on learning strategies has shown that students can be trained in learning strategies and that such training can lead to improved test performance (Weinstein & Mayer, 1985; Rigney, 1980; Dansereau, 1985). However, the results of this study failed to demonstrate that such explicit training enables students to employ learning strategies effectively. This lack of support for the general consensus on strategy training may be due to methodological rather than conceptual reasons. In other words, it remains a defensible claim that training in learning strategies may result in improved performance on concept learning tasks, but specific elements in the design of the lesson materials and in the execution of this study may have contributed to the lack of significant results in the treatments.

Among the factors that may have contributed to the failure to obtain results are the following:

1. The students may not have been developmentally ready to capitalize on the strategy training. While research suggests that children beyond age eleven actively engage in strategy use (Kail, 1979; Flavell, 1977), these particular subjects still may not have had the mature mental capacity to engage effectively in strategy use. Brown and Smiley's (1977) study found that twelfth grade students (seventeen years old) activated strategies to their fullest extent, while seventh grade students (twelve years old) used strategies less effectively. Perhaps a sample of older students would have yielded stronger results.

2. Students may simply not have received enough training in strategy use. When one considers the claim of many learning strategy researchers that before students can benefit from learning strategies in an instructional situation, these strategies must first exist within the individual (Shuell, 1980; Rigney, 1980), it is plausible that a series of three lessons may do very little to compensate for this lack. Students may not have had sufficient time to acquire the strategy. Perhaps training sessions of longer duration may increase the overall effectiveness of strategy acquisition and use.

3. The strategy itself may not have contributed to the attainment of concepts presented. That is, despite the best effort of the investigator to construct a learning strategy that directly aided the attainment of concepts, the strategy investigated in this study may have produced a kind of cognitive overload that confused rather than aided the students. The generation of examples may have competed with the instructional task demands and therefore impeded concentration. While research suggests that example imagery may assist learners in acquisition of the new concepts (Rosch, et al., 1972; 1973; Allen, 1982), the added requirement of putting the example on paper may have discouraged its use.

In addition, the chosen strategy may have interfered with strategies already established by the subjects. Thus, there may have been a second type of competition between the two. It may be fruitful to explore other types of strategies used by students.

4. The specific qualities of the lesson may have contributed to the lack of significant results. The lower mean posttest scores for all students in the study raise the possibility that these materials may have been more difficult than anticipated. Even though the difficulty of the lessons was adjusted, based on the pilot study results, further modifications may be necessary.

Transfer of Learning Strategy Use

Transfer, in general, is very difficult to implement and to investigate (Gagne & Briggs, 1979; Clark & Voogel, 1985; Gagne, 1985). It has yet to be found conclusively in the research on learning strategy generation and use (Weinstein, 1982; Lawson, 1980). Therefore, failure to show transfer in this investigation, although disappointing, may not be that surprising.

1. There may not have been a clear enough connection for students between the training sessions and the transfer sessions. Students may not have had sufficient cues to apply the learning strategy. Derry and Murphy (1986) suggest that an unobtrusive prompt be employed in the new situations to cue learners to use the strategy. Although the experimenter reminded students to use the paper, as they did in the training sessions, and the scratch paper itself was a physical reminder, these prompts may have been too vague for students.

2. Students who received the explicit training (ET) on strategy use may have had less time to complete the actual lesson than those in the other two treatments. As an experimental control, all treatments had the same amount of time to complete the lessons. The ET treatment group had far more work to do since they had to construct concept examples on paper. These students may have elected just to complete the lesson task and not opt to use the strategy. Perhaps allowing more time within the lesson would have allowed students to both use the strategy and complete the task.

3. The results also indicated a significant drop in strategy use among the ET group from the training sessions to the transfer sessions. Thus it may be necessary to require that students in this treatment use the strategy so that a better comparison of performance with the no training group can be obtained.

4. Finally, the overall conditions of the instructional setting may also have influenced the outcome of transfer. The

study was conducted at the end of the school year, when culminating activities of the school and classroom may have taken up much of the students' attention and interest. In addition, the investigation was not a part of the regular classroom routine and students knew that performance would not affect their grades. These conditions may have created artifical setting and interfered with students' participation in the study. Perhaps incorporating learning strategy training within the curriculum would be more effective.

Implications for Future Research

The questions examined in this study are important ones for those concerned with students' ability to generate and use strategies in order to become self sufficient learners. Despite the ambiguous results of this study, it is possible that training in learning strategies may indeed effectively facilitate the acquisition of new concepts. Further research is need to investigate this claim. Such research could proceed in several directions.

First, a beginning point for future research might be to make revisions suggested earlier and conduct a similar study. More reliable measures for assessing students' performance need to be developed. Treatment materials need to be revised to lessen the difficulty for this particular age group. Training time may need to be increased and the use of the learning strategy might be required during the transfer sessions.

Second, further research should examine the variations of strategies employed by students. The types of learning strategies that are most effective with concept learning need to be determined. Subsequent investigations may need to use qualitative methods, such as "think alouds" and interviews, to discover the heuristic strategies that students already employ.

Third, further research should investigate the variations of strategy training. For example, the specific components of the training need to be examined in order to determine their impact on strategy acquisition and use. Studies might investigate the examples used in demonstrating a particular strategy, or the amount of practice necessary for student to acquire the strategy, or the amount and type of feedback used in the training of strategy use.

Fourth, longitudinal studies are needed to investigate the effect of extended training in strategy use on students' acquisition of new concepts. This might be conducted in the form of experimental curricula that incorporates strategy training within a content area. It might be necessary to train teachers in strategy use in order to incorporate the investigation within a regular classroom situation.

Fifth, further investigation should be made into the relationship between ability and strategy training. This research might supply answers to inquiries about how strategies can better serve lower ability students without hindering higher ability students who may already possess strategies and use them effectively. In addition, studies need to consider the effects of strategy training on the middle range of ability as well as the extremes. Such a study could provide practical information in how to implement strategy training into the more typical classroom setting.

Sixth, because the investigation of interactions of strategy training and individual differences is a new area of research (Dansereau, 1985), no definitive conclusions could be made from the findings of the present investigation. However, it is a beginning. More research is needed on the effects of strategy training and uses as they relate to other learner characteristics.

Finally, continued efforts need to be made to understand the transfer effect of strategy training. A study could be devised to investigate the type of prompting needed to envoke strategy use in new situations. The amount and the duration of prompting are also important factors to be investigated.

In summary, the variations and extensions the study just described imply directions for future research. Such studies could suggest ways to train student to use strategies effectively, and thus become self sufficient, competent learners.

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Figure 1.01

Schedule for the Training and Transfer Sessions

Sessions:	Training			Transfer		
	1	2	3	4	5	6*
Treatment:						
ET	PP 1	CL 1	PT 1	CC 2	CC 3 MS 2	MS 3 CC 4
				MS 2	MS 3 CC 2	CC 3 MS 4
ID	PP 1	CL 1	PT 1	CC 2	CC 3 MS 2	MS 3 CC 4
				MS 2	MS 3 CC 2	CC 3 MS 4
NT	CN 0	CN 0	CN 0	CC 2	CC 3 MS 2	MS 3 CC 4
				MS 2	CC 3 MS 2	MS 3 CC 4

* No lessons in Session 6; only tests and opinion survey.

LESSONS:
PP = Prepositional Phrases
CL = Clouds
PT = Propaganda Techniques
CC = Context Clues
MS = Mollusk Shells
CN = Content Narratives on same topic

TESTS:
0 = no test given
1 = lesson
2 = immediate
3 = delayed
4 = retention

Table 1.01

Means and Standard Deviations for Performance Measures for Training Session Lessons

Lesson Posttests	ET	ID	Total
Prepositional Phrases*			
M	6.2	5.5	5.9
SD	1.7	1.5	1.6
n	47	46	93
Clouds**			
M	7.0	6.1	6.6
SD	2.7	2.7	2.7
n	47	46	93
Propaganda Techniques**			
M	6.7	6.4	6.6
SD	2.3	2.4	2.4
n	58	60	118

* Maximum score = 10 items on the post test.
** Maximum score = 12 items on the post test.

Table 1.02

Means and Standard Deviations for Test Scores for the Context Clues Lesson

	Treatments			
Test	ET	ID	NT	Total
Immediate Posttest I*				
M	10.4	10.1	10.5	10.3
SD	2.9	3.4	3.1	3.1
n	55	50	51	156
Delayed Posttest I*				
M	9.3	10.1	10.0	9.8
SD	4.0	3.8	4.2	4.0
n	55	50	51	156
Retention Test I*				
M	9.3	8.9	10.0	9.4
SD	3.1	3.1	3.0	3.1
n**	27	22	26	75

* Maximum score = 20 items per test

** Numbers show that approximately half of the subjects were randomly sampled within each treatment group to complete the test.

Table 1.03

Means and Standard Deviations for Test Scores for Mollusk Shells Lesson

	Treatments			
Tests	ET	ID	NT	Total
Immediate Posttest II*				
M	9.1	9.0	8.7	9.0
SD	4.2	3.5	3.7	3.8
n	55	50	51	156
Delayed Posttest II*				
M	8.8	8.7	8.3	8.6
SD	4.2	3.5	3.5	3.7
n	55	50	51	156
Retention Test II*				
M	7.9	7.4	8.8	8.1
SD	3.9	3.5	3.5	3.6
n**	27	26	25	78

* Maximum score = 20 items per test

** Numbers show that approximately half of the subjects were randomly sampled within each treatment group to complete the test.

Table 1.04

Pearson Product-Moment Correlations Among Cognitive Skills Index & Performance Measures

TEST	PPL	CL	PTL	CCI	CCD	CCR	MSI	MSD	MSR
Cognitive Skills Index	.32a (105)b .001c	.50 (111) .001	.48 (110) .001	.46 (162) .001	.35 (158) .001	.29 (74) .007	.51 (163) .001	.50 (158) .001	.35 (75) .001
Prepositional Phrase Lesson		.34 (111) .001	.29 (110) .001	.25 (105) .004	.25 (103) .006	.06 (45) .35	.27 (109) .003	.34 (106) .001	.22 (52) .06
Clouds Lesson			.32 (117) .001	.32 (114) .001	.26 (109) .003	.27 (51) .03	.47 (116) .001	.40 (113) .001	.55 (52) .001
Propaganda Techniques Lesson				.41 (114) .001	.40 (108) .001	.40 (50) .002	.36 (115) .001	.40 (112) .001	.33 (52) .008
Context Clues Immediate					.51 (163) .001	.58 (77) .001	.37 (168) .001	.38 (163) .001	.32 (77) .002
Context Clues Delayed						.48 (78) .001	.30 (163) .001	.35 (158) .001	.42 (78) .001
Context Clues Retention							.13 (78) .125	.01 (78) .47	N/A
Mollusk Shells Immediate								.56 (167) .001	.63 (78) .001
Mollusk Shells Delayed									.65 (77) .001

a = Pearson Correlation Coefficient
b = number of subjects
c = p value

N/A = Different subject samples for each test

Table 1.05

Univariate Analyses of Ability Effects on Performance Measure Scores

Test	MS	DF	F	P-value
Prepositional Phrase	2.15	(1,99)	12.31	<.001
Clouds	5.38	(1,99)	35.76	<.001
Propaganda Techniques	4.41	(1,99)	29.16	<.001
Context Clues				
Immediate I	7.49	(1,145)	43.65	<.001
Delayed I	14.00	(1,145)	22.46	<.001
Retention I	59.66	(1,70)	6.92	.01
Mollusk Shells				
Immediate II	10.57	(1,145)	51.58	<.001
Delayed II	11.03	(1,145)	44.85	<.001
Retention II	129.93	(1,71)	11.22	.001

Title:

Film-Makers and Persuasive Films: A Study to Determine How Persuasive Films are Produced

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FILM-MAKERS AND PERSUASIVE FILMS: A Study to Determine How Persuasive Films are Produced

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January, 1988

FILM-MAKERS AND PERSUASIVE FILMS: A Study to Determine How Persuasive Films are Produced

"...it can be argued that a majority of our educators have more in common with persuaders than they realize. The truly educational film must not only answer questions but question answers." (Rose, 1962)

Attitude formation and change are important educational goals. Educators are faced with the need to urge learners to accept certain points of view, and to promote certain attitudinal positions. If a fundamental goal of education is to question what is generally accepted, then the function of the persuader in society might be to urge acceptance of that which has been questioned. Whether it is realized or not, educators are constantly advocating one position in preference of another (Rose, 1962).

The field of education deals directly with persuasive messages. The educator's method, in theory, is to give an unbiased presentation of the relevant facts known about a process or a situation and then to let the learner judge. The acceptance or rejection of an idea is theoretically based on the learner's prior knowledge and the ability to evaluate evidence.

Since World War II, when films were used to teach millions of G.I.'s topics such as the basics of hygiene, operation of the M-1 rifle, or the procedures for bracketing with mortar fire, the training film has been a popular and useful tool to the educator. The purpose of a film is based on one of the following: enlightenment, entertainment, or persuasion (Rose, 1963). Educational films must catch the interest, arouse feelings, and involve the student emotionally in some way if the film's idea is to become an intimate functional part of the student's perception and thinking. An educational film will teach very little if the student is merely a passive onlooker (Ashiem, 1955).

The persuasive film is different from other categories of motion pictures because it is designed with attitude formation and change as its primary purpose. They attempt to involve the viewers' attitudes into a message in order to influence them. While most films are designed with some persuasive elements, a persuasive film is defined as one where attitude change is the single most important goal of the motion picture, and where entertainment or enlightenment are included only to contribute to the ultimate goal of persuasion (Simonson, 1981).

The importance of attitude research is often based on the relationship between attitudes and achievement. It has been difficult for educational researchers to identify a direct correlation between the two because of the many external influences on both. However, there have been a number of researchers who have identified a positive link between "liking and learning" (Fenneman, 1973; Greenwald, 1965, 1966; Levy, 1973; Simonson, 1977; and Simonson & Bullard, 1978, for example).

How attitude affects learning is only one reason to measure attitudes. There are other reasons why it is important to know how to persuade. There are times when it is important to promote a certain attitudinal position and encourage students to accept the "truth" of certain ideas. Also, educators need to have an idea of the techniques that affect attitudes of learners in order to avoid influencing them at undesirable times (Fleming & Levie, 1978).

Since Thurstone's landmark study in 1931 that demonstrated films were capable of producing attitude changes in children, many experiments have been conducted to study the relationship between instructional media and attitude formation or change in learners. Numerous studies have shown that films have influenced children. In 1933, Peterson and Thurstone's study demonstrated that films changed children's attitudes, making them consistent with the values presented in the films. Levonian (1960, 1962, 1963) reported that a persuasive film on India produced a significant positive attitude change in viewers. Still more studies that found films could produce attitude change were reported by Allison (1966, on science), Greenhill (1957), Alese (1973) and Reid (1970).

In 1979, Simonson published a list of six guidelines that, if included in the planning, production, or use of mediated instruction, would contribute to the development of desired attitudinal outcomes. These guidelines were based on results gathered from over one hundred research studies on attitudes and media. Establishing the guidelines was one of the first steps toward the development of exact processes needed for producing mediated messages with persuasion in mind.

Simonson's guidelines were used to propose techniques that could be used in mediated messages. Previously, there was little definitive information available in the literature concerning the specific procedures used in persuasive instruction, especially for persuasive films. It can be said that educational films persuade viewers to agree with certain ideas, however, the techniques used by film-makers in the production of persuasive motion pictures that affect attitudes have not been systematically identified, examined, and categorized. There has not been any comparison between what researchers say are the procedures for persuading and what film-makers do when persuasion is their goal.

In 1981, Simonson reported on a survey of award-winning film-makers who were asked to explain the techniques they used when they planned and produced persuasive instructional films. A number of specific techniques, directly related to Simonson's (1979) six guidelines, were identified. However, a low questionnaire return rate made generalizations about the results inappropriate. The study reported in this paper is a modified replication of Simonson's 1981 study. Most procedures were repeated. However, a rigorous series of follow-up steps were followed in order to maximize the number of questionnaires returned.

The purpose of this study was to determine what procedures are used by successful film-makers when they plan and produce persuasive educational films.

METHODOLOGY

Sample

In order to obtain information from film-makers about persuasive films, a list of professional cinematographers was needed. Since the Council on International Non-Theatrical Events (CINE) lists film-makers who have received awards, a current CINE catalog was used to obtain names of "successful" film-makers. Since the purpose of this study was to ask film-makers who were experienced in persuasive film-making to evaluate techniques, and since the nature of this study was descriptive, a random selection of film-makers was not considered necessary. Only film-makers who had "successfully" produced films are listed as Golden Eagle Award winners in the CINE catalog. Golden Eagle Award winning film producers were the target population for the study.

Approximately two hundred film-makers listed as Golden Eagle award winners were sent a copy of the Film Maker Survey (FMS) with a cover letter explaining the purpose of the study. These film-makers were chosen because the descriptions of their films in the CINE catalog seemed to indicate that their motion pictures were persuasive in nature.

THE FMS

In Simonson's 1981 study, an analysis of the characteristics of those film-makers who completed the survey as compared to those who did not return it, failed to reveal any significant relationships that might have indicated that a biased subset of film-makers answered the (FMS) as compared to those who did not. However, the return rate of approximately 34% was considered too low to permit generalizations of results. In spite of the low return rate, it was determined that the FMS was an appropriate measure of film-maker opinions. It had produced consistent and usable results in 1981, and its questions could be related directly to the guidelines for producing persuasive instructional messages. The content of the questionnaire remained generally the same, and only revisions in format and structure were made.

The questionnaire was divided into two parts. Part One dealt with the background and experience of the film-maker. Part Two had the film-makers rate, discuss, or evaluate techniques used in persuasive film-making. Each question in Part Two of the questionnaire was related to one of the six guidelines for attitude change identified by Simonson (1981).

Verification and Distribution of the Questionnaire

Revisions on the questionnaire were minor. A cover letter was written to explain the purpose of the study. The questionnaire was designed to be folded, stapled and returned by mail (postage-paid). Four weeks after the first mailing a second mailing was distributed to non-responders. Two weeks after the second follow-up, a reminder postcard was mailed to non-respondents.

Those film-makers who had not responded at the end of a month were randomly sampled. Twenty film-makers were identified as representative of the non-responding group. The sample were interviewed on the telephone and asked to return the questionnaire in the next few days. The results of questionnaires completed by this group of non-responding film-makers were compared to the results of the responding film-makers to determine if the non-responding subjects answered the questions in about the same manner as the responding group. There were no significant relationships that might have indicated that a biased subset of film-makers answered the FMS as compared to those who did not. A total of eighty-seven questionnaires were returned for a return rate of forty-four per cent.

The data collected were used to determine film-maker's perceptions of the techniques used in the planning and production of persuasive films. The ratings of the techniques were tabulated, and where appropriate, rank orders were established. First, all descriptive statistics were obtained for each question. This included average scores, standard deviations of scores, and the number responding to each question. Next, correlations between all relevant variables were computed. Last, more in-depth analyses of data determined to be interesting based on the descriptive statistics were conducted.

RESULTS

Profile of Respondents

Ninety-five percent of the responding film-makers indicated that film-making was their primary occupation. Approximately sixty-eight (67.8%) percent of the film-makers classified themselves as producer/director, 19% were producers, 2% were directors, and ten percent responded to the "Other" category. The majority of the respondents who chose the "other" category were classified as writers.

The average length of time a respondent had been in the film-making profession was about 18 years. The range was from three to fifty years. Seventy-nine percent of the respondents were males. The average age of all respondents was forty-five. The range from youngest to oldest was twenty-eight to seventy-four years.

Fifty-four percent of the film-makers indicated they had some type of formal training in film-making, and a little over forty-three percent had only on-the-job training. Almost fourteen percent of the sample had less than one year of formal training. Approximately twenty percent had between one and two years of formal training; two percent indicated between two and three years of training, ten percent responded that they had a bachelor's degree, and eleven percent had master's degrees, or more, in film-making. Only seventeen percent reported having had some sort of training in the techniques and theories of persuasion.

The average number of films of all types produced by each film-maker was approximately 102. The number of films produced ranged from one to one thousand. The average number of persuasive films produced by the average film-maker was 67.

The average number of Golden Eagle Awards (the highest award given by CINE) for films of all types received by responding film-makers was 6. The average number of Golden Eagle Awards received for persuasive films was 5. Film-makers reported that the average length of their persuasive films was 24 minutes. Films ranged in length from ten minutes to sixty minutes.

The definition of persuasive film used in this study was considered appropriate by eighty-five percent of the film-makers. Film-makers were nearly equally divided when asked their feelings concerning the market for persuasive films. Twenty-four percent of the film-makers surveyed felt that fifty-one to seventy-five percent of the film market was for persuasive films rather than informative films.

Persuasive Film Production Techniques

One of the major goals of this study was to determine how film-makers would go about producing a film when persuasion was their goal. Film-makers responding to the FMS indicated that they felt a formal prescript writing target audience assessment was important in the production of persuasive films (X = 4.4; 5 = very important, 1 = very unimportant). Fifty-seven percent of the respondents indicated they felt persuasive films were planned and produced differently than other educational films and the degree of difference ranged between very different to somewhat different (X = 1.80; 1 = very different, 5 = almost the same).

In order to determine which production techniques were considered most effective for persuasive films, film-makers were asked their opinion on the importance of a number of techniques. The same techniques were rated in several, different questions by respondents in order to validate ratings and to determine what production techniques were considered most effective for persuasive films. An analysis of these ratings follows.

WHEN COMPARING PERSUASIVE FILM-MAKING TO OTHER FILM-MAKING, HOW IMPORTANT IS IT TO ......

very important 1. use motion in the filmed action
↑ 2. present new information

3. use believable or realistic scenes

4. use an arousing or dramatic musical score

5. use color

6. produce a shorter film rather than longer film

7. use many cuts/scenes rather than few

very unimportant 8. use physically attractive actors/actresses

HOW WOULD YOU RATE THE FOLLOWING IN INFLUENCING ATTITUDES OF VIEWERS IN PERSUASIVE FILMS?

most effective 1. conduct a target audience pre-planning assessment

2. Have actors/people in the film similar to the target audience

3. present inspirational messages

4. include a teacher's guide with follow-up questions

5. Use testimonials

6. use professional actors

7. use a big name star to promote the position

8. use graphs, charts and other visual methods for presenting facts

least effective 9. present verbal information visually through title scenes

RATE THE FOLLOWING TECHNIQUES IN ORDER OF THEIR IMPORTANCE IN THE PRODUCTION OF PERSUASIVE FILMS.

effective techniques 1. "Arouse" the audience intellectually, sexually, or emotionally

2. Make the film "fun" to watch

3. present factual information

4. be as "nonverbal" as possible
5. present both sides of an argument
6. use "talking faces"
7. use "animation"
8. "scare" the audience by presenting the consequences of not following the recommendations of the film
9. use many title scenes

not effective
techniques

The film-makers generally agreed that conducting a target audience assessment and arousing the audience in some way were the most important persuasive film techniques. In another question, film-makers ranked three statements about strategies in film production in order of importance. Of the three, the arousal of viewers emotions was reported to be most important. Technical quality was listed as next in importance, and the presentation of new information was listed as least important of the three.

Almost forty (39.1%) percent of the film-makers felt it was exciting to produce a persuasive film rather than other kinds of educational films (X = 4.1; 1 = very unexciting, 5 = very exciting). Half of the film-makers reported that they always believed in the message of the films they produced. Twenty-one percent thought the message was usually correct and twenty-one percent reported some messages affect them and some did not; one indicated he never became involved with the content of his films.

The sample felt that their persuasive films were relatively effective at changing attitudes of viewers (X = 3.83; 5 = very effective, 3 = somewhat effective, 1 = very ineffective). Over half (67.8%) of the responding film-makers indicated there was a need for more information concerning techniques in persuasive film production.

Film-makers were asked if they ever evaluated the impact of their films. Seventy-eight percent of those responding said they had evaluated the effectiveness of the persuasive films they produced. The following methods for determining effectiveness were given:

	Response	# of film-makers who used technique (n = 68)
1.	comments from viewers	56
2.	results from contests	45
3.	informal surveys	41
4.	sales	37

5.	comments of other film-makers	29
6.	intuition	25
7.	formal experimentation	15
8.	other	11

Summary of Results

Those film-makers who responded to the survey produced a consensus on several techniques and strategies that they felt were important in the production of a persuasive film. Arousing the viewer either emotionally or intellectually and basing the film on an audience pre-assessment were considered important by the majority of the responding film-makers. Other techniques that were listed as somewhat important were:

making the film "fun" to watch

assessing the target audience

using actors that were similar to the target audience

using written teacher's guides and follow-up discussions

using realism that was relevant to the viewer

Techniques that were generally not considered effective or important in persuasive films were:

using title scenes

using animation

"scaring" the audience

using talking faces

using charts and graphs to present facts

using attractive actors

using many cuts/scenes

It is interesting to note that 67.8% of the respondents felt there was a need for more information about the production of persuasive films. This survey identified some of the techniques film-makers used when producing motion pictures, and several techniques that they felt were effective for changing attitudes of viewers.

Film-makers were also asked to list the title of a persuasive film they felt was exemplary. The sixty-nine film-makers that responded to this question each listed one film. Of the sixty-nine films listed, only five films were listed more than once. Each of the five films were only listed twice. Those films that were listed twice were:

Harlan County	Triumph of the Will
War Games	Dark Circles
China Syndrome	

It was interesting to note that two of the five films that were listed more than once were full length features that were box office successes.

Since Simonson's 1981 study had a low return rate (34%), one of this study's objectives was to obtain a higher rate of return. The fact that only forty-four percent of the sample returned the survey was a concern. The unique personality of film-makers, the mobility of members of the film-making profession, and the large number of address changes contributed to the rather low rate of return.

Comments from film-makers on the surveys that were returned added information about the low rate of return. Responses seemed to indicate an unwillingness to agree that a set of guidelines could be developed for persuasive film-making. The overall feeling of the several film-makers who wrote comments was that this survey only "touched the surface" of a complicated subject. Also, film-makers seemed to be reluctant to reveal techniques or procedures that have been successful for them because of the highly competitive nature of film-making. Success is often achieved in motion picture production because of the use of a unique or creative new technique. By sharing their discoveries other film-makers might become equally successful therefore reducing any advantage a film-maker might have. Some of these "artists" might have felt that a knowledge of what makes them "tick" would somehow destroy their magic powers of creativity (Rose, 1963).

The results and conclusions of this study are not a recipe for the development of persuasive messages, but are a guide for further research. As one film-maker said, "It is often misleading or risky to accept generalities drawn from surveys and turn the findings into absolute rules that govern the making of a single film." Other comments described film-making as "an extremely subjective medium," and "a very complex and interesting subject." These comments from the responding film-makers may be evidence of the need for a more scientific approach to the investigation of the art of persuasive film-making.

"For it is only when the doer matures enough to want to understand why he does what he does, more than just intuitively or impulsively, can he consciously and systematically hope to raise the standard of his art to new heights. Until such answers become clear the film maker can only play a game of trial and error. Once understanding enters the process the way is paved for a marriage between the science and the art of cinema" (Rose, 1963).

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Title:

Characteristics of Cognitive Instructional Design: The Next Generation

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CHARACTERISTICS OF COGNITIVE INSTRUCTIONAL DESIGN: THE NEXT GENERATION

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Presented at the Annual Convention of the Association for Educational Communications and Technology, New Orleans, Lousiana, January, 1988

CHARACTERISTICS OF COGNITIVE INSTRUCTIONAL DESIGN: THE NEXT GENERATION

This discussion begins with the assumption that cognitive psychology can make significant contributions to the development of the next generation of instructional systems (for simplicity, the term "instructional systems" will be used to define both instructional design theories and models). Much is known about information processing and cognitive science that could be at least considered, if not incorporated, into existing systems to produce more effective systems. A second fundamental assumption to this discussion is that the number of instructional systems currently available serve useful functions in guiding instruction. At present, little change in the macrostructures, or frameworks, of the various systems appears needed. Instead, major change is encouraged in the microstructures of instructional systems — those aspects of instruction which directly affect the learner.

Current trends in educational technology during the last few years have begun to focus on cognitive rather than behavioral aspects of learning (Case & Bereiter, 1984; Gagne', 1987; Gagne' & Dick, 1983; Reigeluth, 1983). In this discussion, several ideas will be presented to reinforce and strengthen this shift in perspective. The primary purpose of this discussion is to present an overview of useful aspects of cognitive psychology which can be immediately implemented by instructional designers. Lastly, a cognitive instructional design will be presented to help current designers incorporate these cognitive principles. This cognitive instructional design is not meant to be added to the large number of existing models, but rather to be used a supplement or adjunct to existing models.

Premises and Assumptions of a Cognitive Approach to Instructional Design

Instructional design, as with other curricular matters, is not simply an all or none matter. It becomes considerably complicated by the purposes to be served by the instruction. For example, different procedures must be followed when instruction is for training relatively simple processes, such as learning of verbal information, as compared to the processes needed in problem-solving.

In many training situations involving simple processes, such as frequently found in lower-level learning, the learning objectives can be closed (prescribed and well-defined). Here learning is algorithmic, that is, there are certain prescribed steps to be followed. Only behavioral statements of goals and performance are required. The primary function of instruction is to guide the learner's intentions and expectations regarding the goal standards. There are certain prescribed steps to be followed and these have but to be acquired and retained until action is taken.

When the instructional goal involves higher-level learning such as comprehension, understanding, decision-making, and problem-solving, then the complexity of instructional practices takes a quantum leap from the requirements of a simple application. The framework of the instructional system might contain many of the same elements involved in guiding lower-level learning, but the implementation at any one stage involves numerous alternatives. There is a need to consider both declarative and procedural knowledge. The objectives are open rather than closed. Open objectives do not have a ready basis for evaluation and may not be easily predetermined. There may be a host of sub-objectives, some of which may correspond to prerequisite knowledge. In addition, the thought processes that students use in instruction interact so complexly with demands, goals, intentions, and expectations that these processes are not easily identifiable. Rather than learning simply to implement a procedure the student must acquire the ability to recognize patterns, to use context in determining course of action, to discriminate among patterns, to generalize, to understand, and to explain what has been learned. To complicate the matter further, the order of events may change from one occasion to another, that is, although there may be an overall desirable sequence, on many occasions recursive rules (to use but one example) may be appropriate.

Instruction involving higher levels of learning should emphasize a debugging process where sources of error provide useful information for implementation of remediation or repair strategies. Some repair is always necessary in comprehension monitoring when the learner detects faulty reasoning patterns, the use of incorrect rules, a poor solution to the problem, lack of understanding, or failure to comprehend a word or text. The instruction needs to consider (or anticipate) what the learner is doing (or might be doing) at each critical decision point. This can be reduced to three main parts: what is the knowledge base of the learner (prior knowledge); what strategy the learner has decided to use to acquire the skill, ability, or knowledge; and whether the strategy is appropriate to achieve the intentions and goals of the instruction. All of these require effective self-monitoring (internal, or learner-driven) which the instruction can prompt (external, or instruction-driven). This is the debugging process and is dependent upon an understanding of the instructional goals. When errors are made they provide important indications of the rules that students are using and permits attempts to correct those rules. This is a somewhat radical difference from the traditionally behavioral approach which simply provides repetitious exercise on that error without considering the rule that is being used (see, for example, Brown & Burton, 1978).

In summary, a cognitive orientation to instructional design is based on several assumptions (see, for example, Neisser, 1976):

1. The past experience of the learner is represented in a highly intricate network of concepts and relationship among them. These networks, or schemata, direct other behaviors of the learner such as perceptions, expectations, strategies, and plans.
2. The perceptual and motor processes select and explore the learning environment for information relevant to the given learning goals and purposes. Thus, the learner is an active processor of information.
3. The information selected modifies the schemata. In turn, the modification affects the later experiences through the processes used and the information to be selected.

As can be seen this cycle emphasizes the activity of the learner. Hence, the current emphasis in the study of learning and information processing on such activities as orienting activities, learning strategies, and comprehension monitoring. These emphases lead to some secondary assumptions (Holley & Dansereau, 1984, p. xv):

1. The activities in which the individual engages (learner-based activities) in academic or technical learning tasks affect the kinds of outcomes achieved.
2. The effectiveness of the learner's activities can be modified or enhanced through instruction, training, evaluation, and remediation.
3. Instructional strategies and activities (instructor-based activities) have their effect through their influence on the learner's cognitive activities.
4. There are currently available learner-based and instructor-based (or text-based) techniques and aids that can be used as vehicles for enhancing the learner's cognitive activities (Weinstein & Mayer, 1985).
5. These activities can be influenced through the use of aids directly incorporated into the delivery of instruction, they can also be influenced through instructing students how to approach given assignments as an integrated part of the curriculum, or they can be taught to learners in separate curricula as general procedures.

A Comparison Between Behaviorally-Based and Cognitive-Based Instructional Design

The purpose of instruction, regardless of perspective, is to positively influence the acquisition of certain, predetermined learning outcomes. It is believed that the instructional means used to obtain the instructional ends can have a dramatic effect on the qualitative aspects of learning, such as how flexible, durable, and transferable the learning is. It is suggested that the actual determination of the instructional means is dependent largely on which learning perspective, behavorial or cognitive, is taken by the instructional designer. A brief comparison of these perspectives will now be addressed in terms of each perspective's outcome in instructional design.

All designs assume that outcomes depend on an active learner. However, the instructional designer, as cognitivist, might differ from instructional designer as behaviorist in hypotheses about how those activities are engaged in learning. The instructional designer who takes an extreme behavioristic orientation, assumes that the delivery system and definition of the task will wholly determine the learner's activities and should be under complete control of the instructional medium. Note, for example, in the earlier years of programmed learning, the instructional designer spoke of "constructed responses" to refer to cued-responses that had to be supplied by the learner. In addition, such verbs as prompting, fading, and the like assumed learning to be under control of the delivery system. That particular orientation led to ignoring or neglecting what the learner was doing.

The cognitivist, on the other hand, will assume further that the nature of the activity is as important as mere activity. Further the cognitivist assumes that the learner has strategies which may coincide with those expected by the instructor but which may also preempt those the instructor presumes will be used. (Note that the role of learner strategies is not considered within behavioristic orientations). A well-meaning instructor might presume to set as an objective the "meaningful understanding of the subject matter" but simultaneously lectures "from the textbook." The instructor will quickly find that students will follow the textbook and underline those points stressed in the lecture. Rather than develop thinking ability or understanding, the students will fall far short of the goal of meaningful learning because the students' own strategies emphasize the selection of information to be learned in less than meaningful fashion.

Finally, all instructional systems are based, intentionally or not, on the premise that effective time-on-task importantly influences learning. Both the instructional designer and the cognitivist would agree that amount of practice or amount of study is related to degree of learning. Additionally, the cognitivist would be concerned with how the nature of the task would affect the learner's activities (strategies) during the acquisition phase and how these strategies, in turn, would affect the attainment of desired outcomes.

By definition, all designs would be based on the assumption that the aforementioned variables operate interactively. Thus, learning is directly related to the interaction of available and accessible representations of prior learning, the availability and use of strategies by the learner, amount and quality of the time the learner is devotes to the task, the delivery system, and the nature of the evaluation.

A Cognitive Generation of Instructional Design

Some possibilities for improved designs, based on current evidence, will be presented in the subsequent sections of this discussion. The basis for these recommendations rests on recognizing the role played by cognition, or student thought processing, in learning. It is suggested that improvement can only occur when designers actively incorporate findings regarding information-processing into the instructional process. The essential idea is that "research on thought processes examines how instructional presentations influence what students think, believe, and feel and how those thoughts in turn influence achievement" (Clark, 1984, p.2).

The following discussion presents some characteristics of instructional design that are not ordinarily specified in typical descriptions. The points might be considered as a partial listing of criteria by which a given design might be evaluated. Space does not permit an exhaustive and specific enumeration of the specifics of an "ideal" instructional design. Accordingly, only a few examples will be provided.

Objectives

Instructional design models often prescribe the writing of objectives by means of behavioral statements involving stimuli, responses, and performance criteria. Such statements are useful for training situations where performance criteria can be clearly specified. Behavioral objectives provide useful guides for training settings since they help the learner to select relevant information, but left at that point behavioral objectives do not meet the needs of educators concerned with the acquisition of knowledge and thinking skills.

Instructional designers, including curriculum specialists, often neglect the most important of objectives: the objective of achieving comprehension and understanding. Although once an ambiguous construct, there is sufficient literature now existing that can be useful in achieving a definition of understanding, comprehension or thinking. Understanding is an effective objective since it makes provisions for to-be-learned material to be assimilated into the knowledge structure. Such objectives also result in accommodation by a change in the existing structure (that is, a new way of thinking about the material). In the course of such learning, procedural skills that facilitate transfer must also be designated. (From a cognitive view, acquisition of facts is worthless unless there is some provision for teaching the student how the facts can be used).

Failure to attend to the important objective of understanding can be found in many areas of instruction. For example, scientific principles are often learned mechanistically because of the way they are taught. There is a growing body of literature on “misconceptions in science” (see, for example, diSessa, 1982) showing that even when students are familiar with Newton’s Laws of Motion they still apply Aristotelian physics to everyday problems that should be solved by the use of Newtonian physics.

Kinds of Knowledge

Although instruction in declarative knowledge (facts, ideas, and so on) should lead to understanding by the learner, instruction in procedural skills (whether part of a perceptual motor skill or of a cognitive skill) should lead to pattern-recognition and action-sequences (operations) that may or may not use declarative knowledge. Generally, in cognate areas, procedural skills are interlaced with declarative knowledge (as, for example, in proving that two triangles are congruent). With expertise, procedural skills become automatic, freeing cognitive resources for higher-level processes. Acquiring automaticity, however, may take thousands of trials (chess players, for example, take thousands of hours of practice before being capable of attaining “master” status). Instruction in both declarative and procedural knowledge, even though well-practiced, may become welded-to-context (can only be used in limited settings such as only to other school subjects) unless the material is presented in a variety of settings and conditions. This provision for decontextualization must be incorporated into the generation of cognitive instructional designs. Most importantly, it seems that an essential goal of education is to produce learners who can learn on their own, to self-generate precise applications when necessary.

Learning Strategies

It is apparent that the desired outcomes of instruction, even when carefully prescribed and delivered, may not always be achieved because of the complex combinations and interaction of influences that exist in instructional settings. What is learned depends, ultimately, on how the student processes the information. Learning and processing strategies will be more efficient if they are used to perform activities in the same way that learners process information, that is, to the extent that the strategy follows its counterparts in the way the mental operations are conducted (Holley & Dansereau, 1984).

Processing is a complicated operation. It depends on the kind of input or nature of the task, what the student knows, what he/she does, amount of quality-time spent on the task, and so on. However, processing is also dependent on the instructor — what the instructor knows about instructional methods, about the subject matter or skill being taught, about the learner, and so on. Even though instructors know much about these matters, there is the influence of what they actually do. Even though they know a great deal about the subject, the task, and instruction, there is no assurance that they will use such knowledge in the same way as another teacher or that they will use it at all.

Mayer (1984) has presented some examples of teacher-based or text-based aids and their parallels in learner-based strategies. The first level includes aids and strategies designed to help select relevant information from the instruction. Examples of text-based aids at this level include informing the learner of the behavior objectives. The associated learner-based strategy might be underlining or copying. At the next level are aids and strategies for organizing information within the text. Text-based aids here include signalling (e.g., "there are three points to be remembered...", "in summary..." or "the main idea is..."). The parallel learner-based strategy might be structured notetaking, outlining, or concept-mapping. Organizational aids or strategies restricted to the text and used routinely lead to nonmeaningful (verbatim) learning and, thus, only slightly to transfer.

Both selection and organizing are prerequisites for integrating information into the cognitive structure (integration being a necessary condition for meaningful learning). Text-based aids include advance organizers or summaries placed at the beginning of a chapter. Learner-based strategies include the making of elaborations or inferences. These extend the information in the text by adding information that the learner already knows. The use of continuity (making cause-effect relations), adding details, or using analogies and metaphors can be either text-based or learner-based and are other means of linking new information to the cognitive structure of the learner. Material that is integrated, and thereby made meaningful, has the advantage of not only being retained and retrieved more effectively than partially meaningful learning but is also more easily transferred to other learning situations.

Evaluation

The interaction of teacher and student knowledge and activities influences the learning processes, but the outcomes of the process may not be tapped or may be misleading if inappropriate evaluation measures are employed. Whether teacher-made or standardized, the tests used in many instructional settings (outside of training settings) often measure different kinds of outcomes than intended. Such variation may occur at different levels. For example, reading tests are intended to measure comprehension of a passage (text-dependent comprehension), yet may measure what the reader knows rather than what he or she got out of a passage (text-independent tests). Test items selected only on the basis of their statistical characteristics may be found to depend on different processes (e.g., immediate recall of a fact or idea) than those taught or may measure different outcomes than those stated in the objectives. The designer must be concerned with whether items are measuring factual information, conceptual information, problem-solving ability, or transferability. Too often so-called achievement tests measure only the verbatim acquisition of factual information when the desired outcome is the ability to use that information in a transfer situation.

The kind of test administered also interacts with teacher/student variables. Teachers who do not emphasize understanding or who may be under a great deal of extra-school pressure (community, political, and so on) may, for one reason or another, resort to common use of some familiar form of measurement such as multiple-choice tests that tend to establish student expectations about how their performance is to be examined. These expectations influence the way the material is processed; students study for multiple-choice tests differently (perhaps only for recognition) than they do for essay tests (which may require them to study for integration of information), for example.

Timing the Delivery of Components in Instructional Design

In a similar vein, training of teachers in instructional design, or of any instructional procedure, does not necessarily provide assurance that they will use that training. Similarly, timing in the use of a given component of the design is often neglected in instructional designs. Timing of practice or exercises may make a difference in ease of learning. Thus, expert teachers use practice exercises after a unit has been completed, whereas novices assign practice exercises after an "arbitrarily" determined time period, such as the end of a class period, whether or not the student has the necessary skills for conducting the exercises with competence.

States of Knowledge

A frequently overlooked concern in instructional design is how the information in the relatively new investigations of experts versus novices is to be used. There is a vast amount of literature on this topic from a number of sources, ranging from descriptions of the way experts and novices play chess, to what experts recall from the narration of a baseball game, and to the way experts and novices conceptualize physics problems. These studies imply that knowledge in the first stages of learning does not have the same structure as knowledge at later stages of learning. Another premise is that cognitive processes vary with the stages of learning (for example, the selection of superficial features attended to by novices and the selection of fundamentally more sophisticated patterns attended to by experts).

An elementary form of a theory of states of knowledge might be patterned after Rumelhart and Norman's (1978) description of the phases of learning. Their framework is interesting because it conceptualizes learning over the long haul in terms of three phases: accretion, restructuring, and tuning. These phases correspond to early, middle, and later stages of learning resulting in different states of knowledge at each.

Each state implies different methods of teaching, studying, and testing. In the accretion stage new information is delivered in a form that links a new idea with the student's knowledge structure and results in the assimilation of that information. The method of testing is in the form of typical multiple-choice or short-answer tests. Since the knowledge is likely to be stored in relatively isolated form there is high probability of interference from related topics. Transferability in this phase is nil. In the second, restructuring, phase the information already acquired is put into different organizational patterns through such means as the inquiry technique, the discovery method, or the Socratic Dialogue. Interference from related topics is medium. Transferability is high. Appropriate evaluation measures here would be the ability to apply knowledge to new situations and the ability to conceptualize information. In the final, tuning, stage the use of the knowledge (both declarative and procedural) is made efficient through refinement of discriminations, patterns, and skills. Practice under varying conditions is an important teaching device here since new information and skills are not learned, only refined. There is low probability of interference from related information since the information is well-specified and contextually related. Transfer of general information is high, but transfer of specific information is low (because there has been a well developed system of patterns). However, the specific information can be derived from the general information. The appropriate tests for this level of acquisition would be testing under stress, precision in the use of a knowledge or skill, the ability to use deep explanations of classifications, and the ability to use the information in problem solving.

One should note that were we to examine our current instructional practices objectively and closely, we would find that most instruction stops at the accretion phase. Although many, perhaps most, students do ultimately achieve higher states of knowledge, it is because of the tendency of human learners to reconstruct and otherwise organize what they have learned and not because of the deliberate attempts of their instructors or of their textbooks.

Criteria for Effective Instruction

Whatever the instructional design employed and whether the outcome is strategy or knowledge, the desired learning outcome, if achieved, should meet several criteria, most of which are either neglected or ignored in both typical instructional and research settings. These criteria include the following:

1. The achievement should be flexible. The learner should be capable of using the knowledge in at least the variety of settings in which it will be used frequently .
2. The achievement should be durable. Learning the material sufficiently well to "pass" an immediate test is not acceptable. Most information or skills learned will not be

used immediately. Rather, they will be used in a subsequent course, on the job a few months later, or even years later when retraining may be required.

3. The achievement should be transferable. There are minimum requirements here. One, for example, should be able to use "writing a check" procedure for money orders as well. More demanding requirements would be required to employ the principle of refraction to solve problems involving lenses, prisms, rainbows, distortions in visual images when a pencil is placed half way into a glass of water, or "mirages" one may see when traveling over a hot desert road.
4. The use of strategies and knowledge should be self-regulated. This simply means that they can be used on demand by the learner and can be used appropriately for a given situation without the necessity of being cued by an external source such as an instructor ("now use this rule for solving the problem").

Cognitive Affective Considerations

The discussion above has focussed on the acquisition of knowledge and skills, sometimes described as the "cold" side of learning. There is underlying all of this, however, an acknowledgment of the influence of the affective variables (see, for example, Lepper, 1985). Their influence is most readily seen in the concepts of "motivation" and "feedback". Due to their complexity, perhaps, they rarely are employed formally in instructional systems designs. Rather, affective variables often are merely cited as important or described superficially, in descriptions of motivation and feedback as some of the "events of instruction".

Motivation includes both affective and cognitive components. Such motivations may be in the form of motives, intentions and expectations, attributions, anxieties, reward, avoidance of aversive stimulation, informative feedback, acceptance of a model's behavior in social imitation, environmental influences (such as encouragement in the home for reading), or attitudes. There is no doubt that the affective components of learning need to be incorporated into instructional design not only from the point of view of the instructional designer, but from the point of view of the cognitivist as well. But the important role of affective variables, as a consideration in instructional design, is another topic to be developed in the future.

Summary

This section presented many examples of how student thought processing ultimately influences achievement. These views were presented in contrast to the traditionally behavioral orientation which systematically ignores the importance of cognitive processing. The cognitive orientation brings student thought processing to center stage. The cognitive orientation to instructional design is summed up by Clark (1984): "The distinctive characteristic of cognitive research is the idea that instruction influences achievement through student thought processes. That is, instruction influences thinking and in turn thinking influences learning and performance. The cognitive approach therefore assumes that instruction is mediated by student thought processes" (p. 2).

A Cognitively Engineered Instructional Design

In order to serve as an organized conclusion to this discussion, as well as to synthesize the thoughts and ideas expressed, this last section will present a simplified instructional design model which incorporates a cognitive theme. The term "cognitively engineered design" is used to refer to the instruction/delivery systems/learner interface which entails the process of giving learners experiences and training that help them to use and understand the cognitive skills most appropriate for a given learning task and to use the most efficient media for accomplishing the task. This is a slight departure from its use by Norman (1980; 1986) to refer to the science of designing man-machine interfaces, a currently popular theme in design problems raised by the microcomputer revolution. The term "cognitively engineered instruction" applies the increasing knowledge of human cognition to the advances in technology and media as represented in the model displayed in Figure 1.

Insert Figure 1 About Here

This model has the three main parts common to all instructional design models: pre-instructional activities; delivery (or administration) of instruction; and evaluation of learning outcomes as integral parts of an instructional episode. A key difference from traditional design is that design decisions are based on conceptualizations of human cognition and the learner as active rather than passive. As previously discussed, a cognitive orientation allows the instructional designer to make lesson decisions based on how learning, understanding and memory occur rather than via the traditional behavioral position of manipulating input without consideration of the effect of internal events on outcomes. An advantage of a cognitive model is that it brings to awareness important insights into situations where learning does not occur as planned and provides means of revising the design. Both behavioral and cognitive positions provide "ammunition" in the struggle to help facilitate learning, but the cognitive approach provides more information about "where to aim".

Initially, two activities must take place before the instruction can be delivered. The learner's cognitive state needs to be identified while the learning outcomes of the instructional task are defined. For example, if the instructional task is to consider what events led the North to victory in the Civil War, then a great many facts need to be considered quickly and efficiently. A student who is at the accretion stage (and thus is just beginning to acquire the necessary facts about the Civil War) would obviously be unable to handle the problem solving task presented. Hence, the states of the learner and of the instruction are incompatible and mismatched. It would be fruitless to require the learner to proceed with the task and continuing to do so would only lead to frustration for both learner and teacher. By the same token, a learner at the tuning stage has all of the important facts and concepts about the Civil War selected and organized. Activities which continue to review the same facts would prove very tedious and boring. Such learners require experiences which foster accessing and applying that learned information in new and creative ways. For efficient and effective learning to occur, the learner's cognitive state and the learning outcome of the instruction desired should match.

Once the learner's cognitive state and the learning outcome are perceived as compatible, the designers must ensure that the activities and learning experiences presented foster the desired outcome. This second stage in planning the delivery of instruction requires that cognitive processes corresponding to the state of the learner's knowledge (e.g., accretion, restructuring, or tuning) are activated. For example, typical teaching techniques such as the use of mnemonic aids and rehearsal strategies might work well for the accretion stage where the learner is in the process of selecting relevant information for acquisition and storage preparatory to organizing it. But these same activities are relatively poor for higher order processing that would be required as the learner further organizes, integrates, and chunks information into useful schematic knowledge representations. Instead, learning activities might include analogical reasoning, metaphoric representations, elaboration, summarization, identifying cause-effect relations, or spatial mapping. A learner at the tuning stage would benefit from activities that would foster additional elaboration of the lesson material, ability to make applications to a variety of everyday situations or to achieve automaticity in pattern recognition, the use of procedural knowledge, retrievability and so on. Different instructional activities foster (activate) different cognitive processes. Appropriate cognitive processing needs instructional activities geared to achieve the use of specific processes.

Even with these precautions, standardized learning outcomes for all students can never be guaranteed due to the many factors which enter and complicate the instructional setting. Proper evaluation of the type of learning expected can be very difficult especially when this learning is beyond the accretion stage. It would probably be rather difficult (though not impossible) for an instructional designer to construct multiple-choice questions which test students at the restructuring or tuning stage. A variety of testing situations would be necessary to derive an accurate picture of these types of learning. An example of such a testing technique would be to give the student a story without an ending and ask for plausible predictions. As in most instructional design models, if the designated criterial level has not been attained a decision must be made whether to provide the learner with remedial activities such as different strategies or techniques for comprehension monitoring or whether some revision of the instructional level of the curriculum is necessary to adapt to the learners cognitive state or level of knowledge representation and then have the learner recycle through a portion of the program. The remediation box displayed in Figure 1 requires the same considerations regarding processing demands as any other part of the design.

Lastly, it must be remembered that this model has been greatly oversimplified to make the dialogue readable. For example, it is widely recognized that the three cognitive stages discussed (accretion, restructuring, tuning) are not mutually exclusive. A learner is almost certainly interacting with the instructional material at all levels to some extent. The intention of painting this "cognitive picture" of the instructional design process has been to set the stage for understanding the advantages of considering instructional design from a cognitive orientation. Future developments in instructional design should reflect this cognitive view.

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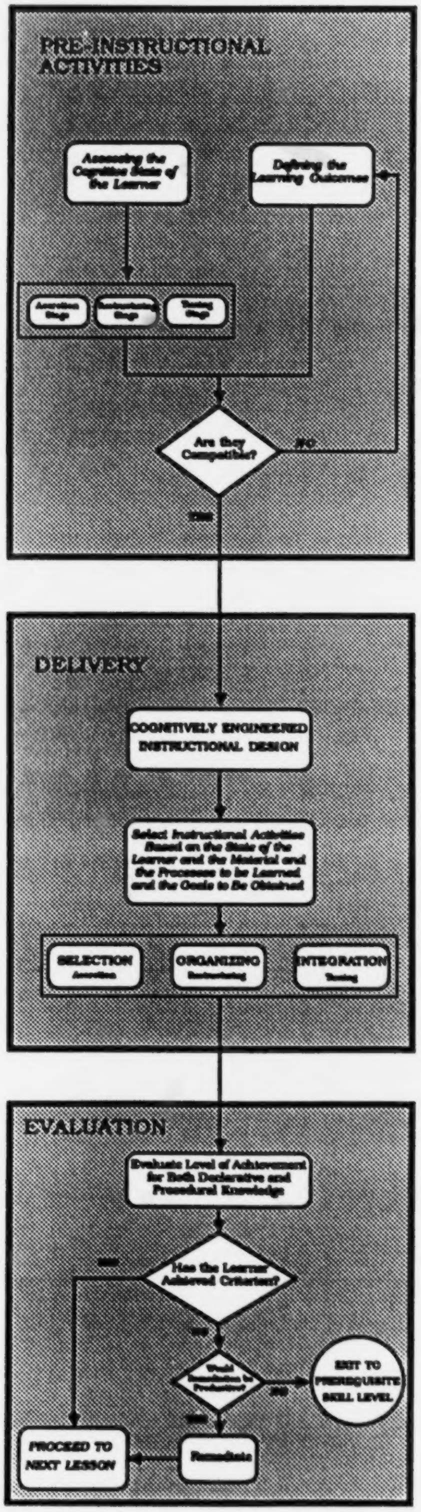
PRE-INSTRUCTIONAL ACTIVITIES
Assessing the Cognitive State of the Learner
Defining the Learning Outcomes
Are they Compatible?
NO
YES
DELIVERY
COGNITIVELY ENGINEERED INSTRUCTIONAL DESIGN
Select Instructional Activities Based on the State of the Learner and the Material and the Processes to be Learned, and the Goals to Be Obtained
SELECTION
ORGANIZING
INTEGRATION
EVALUATION
Evaluate Level of Achievement for Both Declarative and Procedural Knowledge
Has the Learner Achieved Criterion?
EXIT TO PREREQUISITE SKILL LEVEL
NO
PROCEED TO NEXT LESSON
Remediate

Figure 1. A "Cognitively Engineered" Instructional Design Model

Title:

Programming for Effective Concept Learning: Where Should the Branches Go and Why?

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John V. Dempsey
Brenda S. Litchfield

Manuscript for
Proceedings of Select Research Paper Presentations

TITLE: Programming for Effective Concept Learning: Where Should the Branches Go and Why?

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PROGRAMMING FOR EFFECTIVE CONCEPT LEARNING: WHERE SHOULD THE BRANCHES GO AND WHY?

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and Brenda S. Litchfield
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One of the strengths often cited for computer-based instruction is its capacity for providing adaptive learning experiences to students. These experiences may be adaptive in the sense that they provide differential instructional sequences to learners. Or they may be adaptive in the type of feedback they present in response to various answers given by learners. Both types of adaptation present questions to instructional designers as to which instructional sequences or what types of feedback will most effectively facilitate the desired learning.

In two studies to be reported in this paper, we investigate the effects of adaptive sequencing of examples and adaptive feedback on concept learning via computer-based instruction. According to Tennyson & Cocchiarella (1986), concepts are best learned when interrogatory examples of the concepts are systematically presented to develop both discrimination and generalization abilities in the learners. Thus, they recommend that 1) examples be presented in an easy to difficult sequence, 2) examples and nonexamples be presented within a specific context or problem domain (to enhance discrimination), and 3) examples be presented in a number of contexts (to enhance generalization). Finally, attribute feedback is recommended when it appears to be necessary.

In order to enable the systematic creation of examples that embody the recommendations listed above, Driscoll & Tessmer (1985) developed a technique they called the rational set generator (RSG). Examples generated using the RSG range in difficulty from easy to discriminate or generalize to difficult to both discriminate and generalize (see Figure 1). Empirical results have thus far confirmed the effectiveness of the RSG for designing concept examples for use in print instruction (e.g., Tessmer & Driscoll, in press).

Since the RSG is, in essence, a "shell" for creating examples that vary from one another in systematic ways, it also holds promise as a framework for sequencing interrogatory examples in computer-based instruction. For example, students may be presented all of level 1 (easiest) examples, followed by all of level 2 (harder) examples, and so on. Or the sequence may be adapted on the basis of the individual student's pattern of responses. That is, a student making a classification error on a level 2 example may encounter a level 1 example next, while someone answering the level 2 example correctly may go on to a level 3 example. Because the examples are theoretically related in a particular way, different patterns of achievement can be predicted by different instructional sequences.

Learning may also be affected by the type of feedback students receive when they classify examples incorrectly. Some sort of corrective feedback is generally recommended (Kulhavy, 1977), and Alessi & Trollop (1985) recommend increasingly informative feedback after each successive wrong answer, although they admit that empirical support for this recommendation is unclear. Since feedback on concept attributes may be important to correct classification errors, and it was unclear how this might best be provided, this offered a second variable of interest related to the RSG.

Dempsey (1986) designed a template for programming the RSG, and Driscoll & Dempsey (1987) implemented this template with microcomputers and conducted a validation study with concept instruction in educational psychology. To build on those results and begin to investigate the questions of interest discussed above, the current studies were undertaken.

Study 1

The primary question investigated in the first study was: Will an adaptive sequence of interrogatory examples that provides specific discrimination training be more effective for teaching concepts than a simple adaptive sequence? Siegel & Misselt (1984) taught foreign language word associations using a drill and practice CAI program and found that students made fewer errors when they were provided with adaptive feedback combined with discrimination training than when they received adaptive feedback alone.

In the present study, a set of five behavior management concepts (e.g., positive reinforcement, extinction, etc.) were taught using, on IBM microcomputers, the RSG framework for presenting interrogatory examples. Forty-six undergraduate students randomly assigned to the simple adaptive condition progressed to more difficult examples when they gave a correct response, but were branched to a lower level (easier) example when they made an error. Forty-one students in the discrimination training condition progressed in the same way to more difficult examples when they responded correctly. However, upon making an error, these students would be branched to new examples, presented simultaneously, of both the concept that was missed and the one with which it was confused. Then they, too, would next see an easier example than the one on which they erred. Feedback presented for correct and wrong answers was the same for both groups. Both groups were also required to correctly answer the most difficult example of each concept before they could exit the instructional RSG.

Achievement was examined using a 15-item posttest assessing classification of new examples of the five concepts. The examples that comprised this test were established by a previous study to parallel the difficulty levels of the examples in the practice RSG. This test was administered via the microcomputer immediately after the student had successfully completed the instructional RSG. Instructional time and the average number of examples seen by students in each group were also recorded.

It was expected that students in the discrimination training condition would perform better than those in the simple adaptive condition, since they would have received instruction designed specifically to correct a discrimination confusion. Time and number of examples attempted by students were examined because those in the discrimination training group might, by virtue of the extra instruction it contained, encounter more examples and spend more time than students in the other group. If this were to occur, a question of instructional efficiency vs. performance might ensue.

Results. Contrary to prediction, there were no significant differences in either instructional (on the practice RSG) or posttest performance between the two groups. On the posttest, students in the simple adaptive condition scored, on the average, 91.9 percent correct (standard deviation, 10.1) while those in the discrimination training group scored, on the average, 92.1 percent correct (s.d. = 9.6). Performance did improve, however, from instruction to the posttest, with students overall correctly answering, on the average, 78.2 percent of the instructional items and 92.1 percent of the posttest items. This improvement was significant ($T = 11.29$, $df = 86$, $p < .01$).

No significant differences appeared between groups on instructional or testing time, although students in the discrimination training group took an average of 2 seconds longer per question than the other group. Since this group made an average of 2 1/2 % more errors on the first attempt than the simple adaptive group, it is likely that the additional time they took came from answering a few more questions.

Discussion. From our perspective, it seemed that the results observed in this study represented a ceiling effect occurring in student performance. On the average, students missed only one question on the posttest. With such high scores to begin with, there was no room for improvement that could be attributed to the instructional manipulation. What the results perhaps do tell us is that the basic RSG instruction did its job well, and well enough with that particular set of concepts and class of students to require no additional instructional conditions.

Study 2

In Study 2, our purposes were to extend the application of the RSG framework and investigate the effects of different types of wrong answer feedback on concept and rule learning. In this study, we developed and formatively evaluated 4 successive RSGs--one set of concrete concepts, two sets of defined concepts, and one set of rules--for a lesson on drugs. The RSG template was programmed for PLATO and the lesson was implemented as part of a general biology lab taken by mostly freshman college students.

The question of appropriate and effective feedback for CAI lessons is one that has not yet been fully answered. Wager & Wager (1985) assert that more effort has gone toward developing formatting guidelines than to synthesizing learning research for guidance in determining effective feedback. Of particular importance, perhaps, is what learners do with the feedback that is provided. Suppes & Ginsberg (1962) suggested that students should be required to type in a correct answer after an error has been made and feedback provided, and this is a strategy routinely programmed into some CAI lessons. However, Siegel & Misselt (1984) offer the opinion that such a strategy is unlikely to be facilitative of learning unless the student is in some way forced to make the connection between the correct answer and the question.

In the present study, we argued that the type of desired learning outcome should dictate the feedback provided in the lesson. Moreover, both depth of processing studies and studies of elaboration techniques suggest that students who, in some way, more deeply process or elaborate the correct answer following an error should show superior performance to those who do not.

Therefore, we developed four levels of feedback to follow an incorrect response. The lowest level was declarative in nature and required no additional response from the student (e.g., "No, the correct answer is ___. Press return to continue."). The second level involved an elaboration of the correct answer, but still required no additional response from the student (e.g., "No, the correct answer is ___. The reason this is correct is ___."). The third level required students to repeat the correct answer after it was given; how this action was performed depended on the nature of the outcome [e.g., "Type the (name) of the correct answer" (identity items) vs. "Type the letter of the correct answer" (classification questions)]. Finally, the fourth level required some additional processing to be done by the student. This was accomplished by the presentation of a simple multiple choice question following the correct answer that required an answer before the student could continue. These questions, too, depended on the type of learning outcome (e.g., for a defined concept, "The correct answer should include attributes A, B, and C. Which of the examples below contains all of these attributes?").

A "No Treatment" control group was also included in this study to ascertain whether the instruction itself actually had the desired effect. This group did not participate in the instruction, but did take the posttest at the same time it was administered to the experimental groups.

While the course from which students were selected for participation in this study is typically large, on the order of 1100 students per semester, students were not randomly selected. Rather, the coordinator of the course, which is a laboratory course, identified 3 lab instructors she believed would be the most cooperative and perhaps interested in what we hoped to do. Then, for each lab instructor, three lab sections of 20 or 22 students each were randomly selected, two to be designated "experimental" and the third to be designated "control." Thus, we hoped to control as much as possible for a potential "teacher effect."

Since we were not permitted to require participation in the experimental groups, we offered the inducement of "extra points" that students could apply toward their overall grade in the course. Of 120 possible experimental subjects, therefore, 55 students actually participated, spread randomly and approximately equally across the four experimental groups.

Students completed the PLATO-delivered instructional RSG outside of their regular laboratory class times, but took an 18-item objectives-referenced posttest as a part of a regularly scheduled class quiz. This paper-based posttest was developed and evaluated by the experimentors, and given to the lab instructors to administer.

It was expected that all experimental students would perform better as a group than the control students. Within the experimental group, it was anticipated that groups receiving elaborated feedback or feedback that required a response would perform better than the group receiving only the correct answer feedback. In addition, of the two groups required to make a response, those students forced to process the feedback were expected to outperform those who merely repeated the correct answer.

Results. As expected, students who undertook the PLATO RSG instruction performed better on the posttest than those who did not (80.0% to 56.5% ; T = 7.23, df = 96, p < .01). However, no significant differences in performance were observed among the four experimental groups. The posttest means and standard deviations for all groups are displayed in Table 1.

TABLE 1: Average posttest performance in terms of percent correct for four experimental and a no-treatment control group

Experimental Treatment Groups	Mean	S.D.
CA only	78.6	18.8
Elaborated (CA + explanation of CA)	81.2	15.5
Forced repetition (CA + "type CA to continue")	84.8	9.3
Forced processing (CA +	76.7	16.4
No Treatment Control Group	56.5	16.6

An analysis of covariance, with the course final exam score serving as the covariate, was conducted on posttest scores for the experimental groups. While the final exam score explained approximately 15% of the variance [F (1,52) = 9.25, p < .05], the main effect for group explained only 2% [F (3,52) = .44, ns]. In view of these overall results, no additional planned comparisons were undertaken. We also observed that students' scores under one of the three teachers were consistently lower than other students, but this effect did not appear to interact with expected effect of type of feedback on performance.

Discussion. The results of this study offer little in the way of definitive answers to the question of what is appropriate and effective feedback for CAI lessons teaching concepts and rules. In effect, it demonstrated only that adaptive practice with some sort of feedback is better than none at all, or at least that which students will do on their own left to their own devices. Perhaps we may also conclude that feedback specifically designed according to the type of learning outcome is effective.

It is interesting, however, that students forced to answer an additional question after they made a wrong response performed less well than all other groups. We can only speculate at this point that they may not have followed directions in this condition as much as we expected. That is, we observed in this class of students a general distaste for reading. Since the forced processing condition required much more reading than any of the other conditions, students may have pressed any answer to continue rather than taking the time to read and answer the additional question.

General Discussion

Taking these two studies together, what can be concluded? Unfortunately, less than we had hoped. In both studies, the RSG framework, shown previously to be useful in print instruction, appeared to be equally effective for use in computer-based instruction. Students learned from their practice on the instructional RSGs, and produced, as a consequence, very acceptable performances on posttests covering the same material.

Given that neither experimental manipulation conducted in these studies produced statistically significant effects, we are left with questions. Will type of adaptive sequence, or type of feedback, have the predicted effect on performance under other conditions? Of so, what are they? Or, does the RSG framework have strong enough effects itself on performance to mask other potential effects?

We anticipate that planned future investigations and replications may help to answer these questions and may shed some light on the original problem with which we began this research: Where should we put the branches in CAI lessons to facilitate concept learning, and why?

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Figure 1

Model Matrix of a Computerized Rational Set Generator
(from Dempsey, 1986)

		GENERALIZATION		
		LEVEL 1	LEVEL 2	LEVEL 3
DISCRIMINATION	CONCEPT A	A1	A2	A3
	CONCEPT B	B1	B2	B3
	CONCEPT C	C1	C2	C3

Title:

Cognitive Style, Cognitive Ability, and the Acquisition of Initial Computer Programming Competence

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Cognitive Style, Cognitive Ability, and the Acquisition of Initial Computer Programming Competence

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Running head: COGNITIVE STYLE AND PROGRAMMING

Abstract

This study examined the relationship of cognitive style and ability to the initial acquisition of computer programming competence. The selected cognitive style (field-independence) and three cognitive abilities (Logical reasoning, spatial, and direction following) were correlated to five programming component skills. The five programming component skills measured in this study included; (1) knowledge of BASIC syntax, (2) ability to predict program outcomes, (3) ability to design and write programs, (4) ability to debug, and (5) ability to modify programs in BASIC. Forty-six college students in a computer literacy course participated in this study. Results indicated that field-independence, logical reasoning and direction following were strongly relate to most programming skills. Spatial ability was related to only debugging and modification.

Cognitive Style, Cognitive Ability, and the Acquisition of Initial Computer Programming Competence

The curriculum of computer literacy has been controversial since first introduced as a course of study, and remains an unresolved issue. Computer literacy curricula have included one or a combination of following content; computer programming, computer applications, and use of hardware and software. In recent years, the focus of curriculum has shifted from programming language learning to computer application. However, proponents for teaching programming in schools argue that computer technology is a multi-purpose technology. Therefore, the powerful ideas that underlie programming enable students to communicate and interact with a myriad of other computer applications (Soloway, 1987). Most teachers who include computer programming in computer literacy argue that programing provides a hands-on computer experience in an environment where students are in control (Luehrmann, 1981). Programming has become an integral part of many computer literacy curricula.

Programming is complex and novice programmers bring a variety of cognitive skills and styles to the challenge of programming. Individual differences that exist prior to learning new skills are important instructional conditions for planning instructional treatments. However, the relationship between competence in computer programming and cognitive characteristics in learners has not been well researched (Linn, 1985).

Objective

The objective of this paper is to describe the relationship between one cognitive style and five programming component skills, plus, the relationship between three cognitive abilities and five programming component skills. The single cognitive style selected for this study was field independence. The three cognitive ability factors were logical reasoning ability, spatial ability, and direction following. The five components of computer programming success were: syntax, program comprehension, program composition, debugging and program modification.

Background

Considerable research has been conducted to identify factors that are associated with programming outcomes. Findings suggest that there is a positive relationship between programming outcomes and cognitive variables (i.e., general intelligence, mathematical ability, academic achievement). Therefore, it is plausible to hypothesize that individual difference in the initial acquisition of programming competence may be related to cognitive style and cognitive ability.

Cognitive Style

Cognitive style refers to the manner in which individuals process information; how they think (Witkin, Moore, Goodenough, & Cox, 1977). According to cognitive style theory (Ausburn & Ausburn, 1979; Messick, 1984; Kolb, 1984), individuals develop a preferred way of thinking, problem-solving, and interacting with the environment. A commonly identified cognitive style in relation to academic achievement is the field-independent/field -dependent continuum. This style is identified by the Embedded Figures Test (EFT) or Group Embedded Figures Test (GEFT) which measures subject performance on a series of problems in which the subject must find a simple figure in the context of a complex set of figures.

Field-independent learners tend to impose structure on a field if a logical pattern does not exist, whereas field-dependent learners accept the field the way it is (Witkin, Moore, Goodenough, & Cox,1977). In addition, field-independent learners appear to have greater skill in "cognitive restructuring"; that is, in understanding problems and reformulating problems into structured ideas. Skill in cognitive restructuring has been found to be related to success in mathematics and in the physical sciences (Witkin, Moore, Goodenough, & Cox, 1977). Computer programming seems to demand cognitive skills which have been developed by field-independent learners. Programmers often have to reformulate problems into structured ideas and detect irregularities in programming logic. Similarities between cognitive skills used by field-independent learners to solve novel problems, and cognitive requirements for computer programming has led several researchers to hypothesize a relationship. Many have found a moderate but positive relationship between field-independence and computer programming success (Stevens, 1983; Webb, 1985; Bradley, 1986).

Cognitive Ability

Snow (1980) suggests that cognitive ability can be further subdivided into two categories based on cognitive functions. Crystallized ability (general ability) is an ability to apply accumulated learning skills to the acquisition of new skills (general intelligence, mathematical ability), whereas fluid cognitive ability (specific ability) is a skill that is needed to modify performance requirements (i.e, spatial, reasoning, following directions). Snow (1980) also suggests that when a learning task is novel to the learner, fluid ability is more relevant than previously crystallized learning skills.

Since learning to program is a new experience for most students seeking computer literacy, fluid ability may be more closely related to computer programming success. In addition, numerous studies have correlated programming success and crystallized ability (i.e, mathematical, verbal, academic achievements in mathematic or science) suggesting that mathematical and academic achievement is a strong predictor of programming success (Peterson & Howe, 1979; Mazlack, 1980; Konvalina, Wileman, & Stephens, 1983; Fisher, & Mandinach, 1985; Webb, 1985; Mayer, Dyck, Vilberg, 1986; McCoy & Burton, 1987).

General ability is often a combination of many specific cognitive abilities. Most computer programming aptitude tests measure general ability, and show a moderate correlation between test scores and programming performance (i.e, IBM Programmers Aptitude Test, Aptitude Assessment Battery-Programming). However, these findings are of little value in developing an instructional treatment to meet the differing needs of individual students. As Webb (1985) points out "...since programming aptitude tests typically assess a combination of abilities, it is difficult to determine whether some abilities are more important than others for predicting performance" (p.184).

Programming and individual differences

Programming is made up of component skills (Shneiderman, 1980; Pea & Kurland, 1983) and each skill may favor a different cognitive ability or cognitive style. Several studies have explored the relationship among cognitive style, cognitive ability and computer programming performance in children and precollege students (Fletcher, 1984; Webb, 1984, 1985; Bradley, 1986; Pommersheim, 1986; McCoy & Burton, 1987). However, only a few studies (Snow, 1980; Mayer, Dyck, Vilberg, 1986; Werth, 1986) have examined the relationship of cognitive style and ability in adults. Snow (1980) correlated diverse individual characteristics with programming outcomes. He found that only two of the many individual characteristics were significantly related to learning BASIC at college level. He concluded that fluid analytical ability was more important than general crystallized ability in predicting a learning outcome.

Mayer, Dyck, & Vilberg also found logical reasoning and spatial ability to be significant factors in learning BASIC. However, they suggested that specific cognitive skills such as direction following, word problem translation, and procedure following were better predictors of learning BASIC. Werth (1986) found that field-independence was significantly related to course grade in an introductory PASCAL course. Since computer programming requires a combination of many skills, examining the relationship between a specific cognitive factor and several programming component skills may impact upon programming instruction. However, only a few studies have examined specific cognitive predictors in regard to programming component skills. Webb (1984, 1985) found that spatial ability was the best predictor for knowledge of LOGO and BASIC commands, and that field-independence was moderately related to programming skills in LOGO, but not in BASIC. These findings provide insight into the cognitive requirement for novice programming, but more research is needed to better understand the relationship between individual differences and programming outcomes. The selected cognitive factors also need further investigation in order to apply general findings to adult novice programmers, since it is not certain that the cognitive skills of young children and the cognitive skills of adults predict the same outcomes in learning computer programming.

Method

Subjects

Forty-six students who enrolled in a computer literacy course during the fall term of 1987 participated in this study, to include, seventeen graduate students and twenty-nine juniors and seniors in the school of education. Their ages ranged from 21 to 46. Sixteen students reported that they had used word processing, spreadsheet, or other application software, but only six reported that they had any knowledge of programming in BASIC, Pascal, or Logo.

Instrumentation

Cognitive style

Cognitive style was measured by the Group Embedded Figures Test (Oltman, Ruskin, & Witkin, 1971). Subjects were presented with a complex figure and were asked to find a simple figure embedded in the complex one. The tests were 10 minutes long, and consisted of 18 complex pictures. Scores could range from a perfect 18 correct to zero correct. A high score indicates field-independence while a low score indicates field-dependence. Test validity and reliability have been established for the GEFT (Witkin, Oltman, Raskin, & Karp, 1971). Using correlations between parallel forms, a reliability estimate of .82 was determined.

Cognitive ability

The three cognitive ability tests were timed, paper-and-pencil tests, and all were selected from a Kit of Factor-Referenced Cognitive Tests (Ekstrom, French, and Harman, 1976). Because of time constraints, only Part A of each test was used in this study. The manual stated that these tests were valid for grades 9 through adults.

Spatial ability was measured by the Paper Folding Test. In this test, figures were drawn to show each step of paper folding. The last figure contained one or two holes to indicate where the paper had been punched. Subjects were asked to choose one of five figures that showed the correct pattern of hole punches. The test was 3 minutes long and consisted of 10 items.

Logical reasoning was measured by the Letter Sets Test. Five sets of letters were presented with four letters in each set. Four of the sets were alike in some way. Students were asked to find the odd set. The test was a 7-minute timed test and consisted of 15 items. The reliability of the test was .77.

Direction following ability was measured by the Following Directions test. Subjects were asked to determine the correct letter in a matrix of letters by following a complex set of directions (e.g. "Which is the only letter that appears directly above the letter A?"). The test was 7 minutes long and consisted of 10 items.

Programming competence measure

Four programming tests were given throughout the treatment period. Each test included items to assess knowledge of syntax, ability to interpret a program (comprehension), ability to design and generate codes (composition), ability to find mistakes in the existing program (debugging), and the ability to restructure a given program by adding or changing codes (modification). Each test included the five component skills. For example, to test syntax knowledge, students needed to recognize BASIC syntax in a list of correct and incorrect statements. To test comprehension, students predicted outcomes from a short program (6 to 20 lines). To test program composition, students were asked to generate a program after reading one or two paragraphs which described a problem to be solved. To test program debugging, students had to find and correct mistakes in both syntax and logic. To test program modification, a function of an existing program was provided and students were asked to add more programming codes to produce different outcomes.

Each item for programming comprehension, composition, debugging, and modification was scored on a scale of 0 to 10, making partial credit possible. Construct validity was determined by asking three programming instructors to act as judges. They were asked to identify the category of each question based on criteria provided by the researcher. The interjudge agreement was 100% for syntax, comprehension, and composition, and 93% on debugging and modification.

Procedure

Course content consisted of computer application, issues in educational computing, and BASIC programming. Four cognitive pretests, measuring cognitive style and ability, were administered during the 3rd week of the semester. BASIC programming began during the fourth week. Four tests were given to students during the 9-week treatment period. Programming tests were given at intervals for two reasons: First, in order to increase the reliability of subskill tests, several items for each component skill had to be asked. Students would be overwhelmed with one test. Second, tests served as an instructional activity as well as an evaluation tool.

During the instructional treatment period, students were guided by lecture and a textbook (Computer Literacy: A Hands-On Approach, Luehrmann & Peckham, 1986). Program design, debugging, and modification skills were emphasized as students learned programming concepts. In addition to in-class work, five programming assignments were required for a course grade.

Data Analysis and Results

Out of 46 subjects, 45 completed all cognitive pre-tests and all programming exams. Field-independence was treated as a continuous variable rather than a dichotomous variable. Logical reasoning, spatial ability, and direction following were scored by counting correct answers. A scoring scheme was developed for computer programming items. Syntax answers were judged either true or false, not allowing for partial credit. Scores in other categories were graded on a scale of 0 to 10, so that partial credit could be given for partially correct answers.

To examine the relationships between cognitive variables and computer programming competence, intercorrelations among computer programming subscores, cognitive style, and cognitive ability are presented in Table 1.

Insert Table 1 here

Field-independence was moderately related to all of the computer programming competence scores ($p <.01$). Logical reasoning and direction following were significantly related to most computer programming skills except the syntax score ($p<.001$). Spatial ability was related to programming debugging and modification in this study. Previous findings of a positive relationship between spatial ability and computer programming success was based on a composite score (Snow, 1980; Mayer, Dyck, & Vilberg, 1986). Therefore, it is difficult to compare previous findings to findings in this study. It is interesting that spatial ability is related only to those skills considered complex (debugging, modification). It is reasonable to assume that the ability to transform one image into another may be important in debugging and changing programs.

Although the focus of this study was to determine the relationship between cognitive variables and computer programming competence, intercorrelations were also examined in order to examine the effect of these factors upon learning computer programming.

Field-independence is related to the other three cognitive ability variables. Spatial ability is related to only field-independence. Reasoning is related to field-independence and direction following. Direction following is related to field-independence and logical reasoning. The strong relationship between direction following and logical reasoning may imply that these two variables were strongly related to all programming skills except the knowledge of syntax.

Relationships between cognitive style/cognitive abilities, and the initial acquisition of computer programming competence were examined. Four conclusions were drawn from data. (1) Logical reasoning and direction following were strongly related to program comprehension, composition, debugging, and modification. (2) Spatial ability is only related to debugging and modification, (3) Cognitive style is moderately related to all of the five programming skills: Syntax, comprehension, composition, debugging, and modification. (4) Cognitive style is related to knowledge of syntax but cognitive ability is not related to knowledge of syntax.

Based on Shneiderman's syntactic and semantic model, programming component skills were subdivided to examine the relationship between the 4 cognitive variables and the 5 computer programming component skills. A strong relationship between logical reasoning and programming coincides with previous findings (Mayer,Dyck,& Vilberg, 1986). This suggests that logical reasoning is similar to processes that are required in programming. According to Wardell (1973), induction is largely a synthesizing process. Program composition, debugging, and modification require the assembling of program statements into a logically sequenced program list. However most novice programmers find it more difficult to write or debug programs than to learn language features (Linn, 1985). Findings of a positive relationship between logical reasoning and all programming skills but syntax seem reasonable, since the knowledge of syntax is acquired by rote learning rather than by applying a synthesizing process.

A positive relationship between direction following and programming is expected because programming involves procedural skills such as sequencing and tracking statements. Direction following is referred to "integrative process" which is an ability to keep in mind simultaneously, or to combine several conditions to produce a correct response (Ekstrom, French, & harman, 1975). Program comprehension, composition, debugging, and modification require close tracking of function of statements as well as their relationship to other statements. Finding of a relationship between direction following and programming is particulary valuable, because following directions is a specific skill that may be trainable than skills of general ability (Mayer, Dyck, Vilberg, 1986). Since direction following (a procedural skill) seems related to success in learning to program, procedural skills may be developed through instruction. Although procedural skills are employed in many problem solving situations, these skills are not explicitly taught in schools. A nonsignificant relationship with syntax and direction following is also expected because knowledge of syntax is acquired by rote learning.

Field-independence was moderately related to all of the five programming components. The similarity between cognitive processes which field-independent learners employ and cognitive processes that are required for programming anticipates a positive correlation between the two. Indeed, several studies have reported a positive relationship between field-independence and programming (Webb, 1984; Bradley, 1986; Werth, 1986). Webb (1985) and Bradley (1986) found that field-independence was related to LOGO programming achievement scores with small children. Werth (1986) found a significant relationship between field-independence and PASCAL programming success. The current study found a relationship between field-independence and the acquisition of initial programming competence in BASIC with adults. In spite of different languages and age groups, the consistent positive relationship between programming and field-independence suggests that "cognitive restructuring" is important in learning to program. Data from the current study also suggests that field independence seems to underlie other cognitive abilities because of the significant correlation between GEFT scores and logical reasoning, spatial, and direction following.

A positive relationship was found between spatial ability and programming debugging and modification. The current study findings on the relationship between spatial and other component skills (syntax, comprehension, composition) do not support Webb's findings (1984). However, she used LOGO language to examine the relationship between spatial ability and the acquisition of syntax, program interpretation, and program generation. It is possible that adults recognize BASIC syntax more easily than precollege students, because a significant relationship was found between spatial ability and more cognitivly demanding tasks such as program debugging and modification. Also, the conflicting results on program comprehension and composition between Webb's study and the current study may be due to different languages used.

In summary, field-independence, logical reasoning, spatial ability, and direction following were found to be related to computer programming. The importance of logical reasoning and direction following have been found in this study. The lack of a relationship between the knowledge of syntax and cognitive ability should be investigated further in future studies.

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Table 1

Intercorrelations Among Computer Programming Subscores, Cognitive Style, and Cognitive Ability

	Syntax	Compre	Compo	Debug	Modif	Style	Spatial	Reason
Style	.279*	.359**	.385**	.430**	.371**			
Spatial	.027	.236	.250	.288*	.323*	.434**		
Reason	.221	.640***	.528***	.537***	.532**	.468***	.231	
Direction	.244	.600***	.570***	.505***	.462**	.365**	.188	.642***

Note: N=46 * $p < .05$ ** $p < .01$ *** $p < .001$

Title:

The Dance of Education

Author:

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The Dance of Education

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Paper presented at the annual conference of the Association for Educational Communication and Technology, New Orleans, Jan. 1988.

"Our minds encompass planetary movements, mark out geological eras, resolve matter into its constituent electrons, because our mentality is the transcendental expression of the age-old integration between ectoplasm and non-living world."

Earnest Everett Just, Biologist

"We cannot doubt the existence of an ultimate reality. It is the Universe forever masked. We are a part of an aspect of it, and the masks figured by us are the Universe observing and understanding itself from a human point of view."

Edward Harrison, Cosmologist

"The passion for science and the passion for music are driven by the same desire: to realize beauty in one's vision of the world."

Heinz Pagels, Physicist

Introduction

Science has long fingers. Because it reflects a way of thinking, it frames our imagination, our investigation, and our invention. The questions we ask, the manner in which we derive answers, and the eventual solutions proposed to problems all become exemplifications of the current scientific mode of thinking. Thus, science influences our technology, our politics, our research, and our institutions.

It is a commonly held assumption today that education should be a science. Point in fact, most universities and colleges of education bestow the degree of B.S., rather than B.A. on their graduates. Implicit in such an assumption is the belief that the products and processes of science and technology can provide benefits, if not solutions, to the problems in the field of education. Yet, science has undergone some major paradigmatic changes during this century that need careful examination if educators are to attempt to apply principles from it.

This article begins with an overview of the changes in science, specifically physics, and ends with the proposition that education is currently entrenched with an outdated scientific mode of thought, that of a Newtonian model. It proposes that the more contemporary model of relativity be applied which purports that wholes can not be broken into parts, variables are not isolable but interrelated, and that change is a dance of interaction, organization, and adaptation.

Brief History of Science

During the Middle Ages science was based on a unification of reason and faith, its main goal being to understand the meaning and significance of natural phenomena. God, the human soul, and ethics were interwoven into a view of the world as organic and living because causal explanation and human or divine purpose were confused and superficial.

With the advent of the "Age of the Scientific Revolution" in the sixteenth and seventeenth centuries, a rigorous determinism became prevalent with objective relationships attributed to causal events, epitomized by the theories of Bacon, Descartes, and Newton. Bacon advanced the notion that "nature had to be hounded in her wanderings...bound into service and made a slave" (Capra, 1982, pg.56). He set forth the empirical method of induction, the expressed goal being to dominate and control nature. Descartes, with his famous idiom "Cogito, ergo sum" -- "I think, therefore I exist" encouraged a division between mind and matter which led to a view of the universe as a mechanical system consisting of separate objects, fundamental building blocks whose properties and interactions were thought to determine all natural phenomena. A brilliant philosopher and mathematician, Descartes formulated the principles of deductive reasoning and set forth the framework of the cartesian coordinate system, both of which became the basis for a reductionist, empiricist view of the world. Newton cemented this perspective by describing space and time as "absolute... without regard to anything external" (Capra, 1982, pg. 65). His mechanics were based on certain principles of conservation which produced the idea that all that happened had a definite cause and effect, and that the future of any part of a system could be determined with absolute certainty if its present state was known in detail and the appropriate measurement tools were available.

Contemporary physics suggests a new paradigm. For example, Faraday and Maxwell while studying electric and magnetic forces discovered that it made more sense to talk about a "force field" rather than a force. They determined that each charge created a disturbance in the space around it so that the other charge felt a force. In contrast to Newton's theory, the force field had its own reality and could be studied without any reference to material bodies.

During the 1800's light was believed to be composed of waves. Thomas Young had shown convincingly that when a beam of light was projected through a razorlike slit (smaller in diameter than the wavelengh of the light), interference (diffraction) occured. This diffraction could only be explained by a wave theory. Planck and later Einstein proved, in contradiction to Young's theory, that light was composed of small particles (called photons) travelling in a similar fashion to billiard balls. When they hit an object they hit an object they knocked a particle out of the mass of that object, just as a billiard ball hitting another would send it traveling at the same speed as the original ball. This proposal explained refraction and the photoelectric effect, whereas the wave interpretation had been insufficient, but a paradox remained. How could light be particles with mass, and yet be waves at the same time? Einstein resolved the contradiction by proving that light was both. He proposed that light is nothing but a rapidly alternating electromagnetic field traveling through space in the form of waves. Whether we perceive light as photons (having mass) or as waves depends on the observer, the question asked, and the measurement system used. Sachs comments on Einstein's theory...

> "The real revolution that came with Einstein's theory...was the abandonment of the idea that the space-time coordinate system has objective significance as a separate physical entity. Instead of this idea, relativity theory implies that the space and time coordinates are only the elements of a language that is used by an observer to describe his environment." (Sachs, 1969, pg. 53)

Present day quantum physicists have verified repeatedly Einstein's description of the effect of the observer and the interconnectedness of variables such as space, time, and momentum. Subatomic particles have been found by Heisenberg, Bohr and others to have no meaning as isolated entities. To the extent that a particle can be studied in terms of its placement in the atom, the momentum becomes ambiguous. And vice-versa. In other words particles are now understood as waves dancing between states of mass and energy. In the words of Neil Bohr, "Isolated material particles are abstractions, their properties being definable and observable only through their interaction with other systems" (Capra, 1984, pg. 124).

Present day "Bootstrap" and "S-Matrix" theory physicists assert an even more radical perspective. In Capra's words,

> "Bootstrap philosophy constitutes the final rejection of the mechanistic world view in modern physics...In the new world view, the universe is seen as a dynamic web of interrelated events. None of the properties of any part of this web is fundamental; they all follow from the properties of the other parts, and the overall consistency of their mutual interrelations determines the structure of the entire web." (1982, pg. 93)

In essence, bootstrap philosophy accepts no laws at all except that of self-consistency. All the parts of matter must be consistent with each other. To that point Heisenberg states, (when we observe).. "What we observe is not nature itself, but nature exposed to our method of questioning."

The concept of mass as nothing but a form of energy, and particles, not as building blocks, but as "dynamic patterns continually changing into one another--the continuous dance of energy" has led some (Capra, 1982, 1976; Zukav, 1979) even to go so far as to suggest a parallel between current physics models and eastern mysticism, i.e. Taoism. In Taoism, change is not seen as occurring as a consequence of some force, but rather as a tendency which is innate in all things and situations, arising from the dynamic interplay between the polar abstractions of yin and yang.

Yin can be understood metaphorically by equating it to the earth, moon, night, winter, interior. It corresponds to all that is contractive, responsive, and conservative and is sometimes related to the more feminine side of nature, meaning receptive, reflective, and intuitive.

Yang, on the other hand, can be associated with heaven, sun, day, summer, surface. It implies all that is expansive, aggressive, and demanding, and serves as the masculine counterpart of nature, meaning assertive and controlling.

Waves dancing to become mass exemplify the yin pole; the expansive dance to become energy, the yang. The more electrons are constrained by a "yin" pull, the faster and faster they dance (yang). The contractual pull gets complemented by the momentum and expansion pull, keeping the atom in optimal, dynamic equilibrium. These "pulls" are not exterior forces but arise out of the inherent nature of matter. Just as the mystics speak of too much of either pole as destructive, so too contemporary physicists. While too much contraction results in black holes, too much expansion results in burning suns.

Influence of Early Science on Education

This new scientific world view is vastly different than the one utilized in education today. To date, although many different models have been tried, they all seem to stem from two basic perspectives, either empiricism or maturationism. While empiricists rely too heavily on a controlled, Newtonian view, maturationists can be criticized for their sole reliance on the internal, natural development of the child, a view reminiscent of early science.

Empiricism

Definition. Empiricism is defined by Webster as "the theory that all knowledge originates in experience". Generally, empiricists hold that knowledge is a copy of a world exterior to the self. Stimuli effect the learner and are processed. Each experience or observation adds to prior ones, thus knowledge is the sum total of observations the learner has had. No a priori thought on the part of the learner is assumed. Empiricism is frequently equated to logical positivism which holds that all meaningful statements are either analytic or conclusively verifiable or at least confirmable by observation and experiment.

Empiricism in education. The empiricist viewpoint in education takes the form of preplanning a curriculum by breaking a content area or skill into assumed component parts or subskills and then sequencing these parts into a hierarchy ranging from simple to more complex. It is assumed that observation or experience at each of these sub levels will quantify to produce the whole, or more general concept. Further, learners are viewed as passive, in need of motivation, and effected by reinforcment. Thus, teachers spend their time developing a sequenced, well structured curriculum and determining how they will assess, motivate, reinforce, and evaluate the learner, before they have even met him/her! The child is simply tested to see where he/she falls on the curriculum continuum and then expected to progress in a continuous, quantitative fashion.

Bloom's mastery learning model is a case in point. This model makes the assumption that wholes can be broken into parts; that skills can be broken into subskills. Learners are diagnosed as to the level or subskill needed, then taught until mastery is achieved at each level. Further, it is assumed that if mastery is achieved at each level then the more general skill encompassing the parts has also been taught. Learners are assessed at each stage, because in true logical positivist fashion it is believed that learning can be conclusively verified by observation and experiment. The effect of simply asking a question, or testing, is rarely considered, or if considered is usually cast empirically.

Problems. A recent study in the Chicago Public School System (1985) found an empiricist educational technology to have some problems. The Chicago schools adopted a mastery learning approach in their reading instruction programs, K - 6. The subskills such as beginning consonant sounds, vowel sounds, ending consonant sounds, consonant blends, vowel digraphs, and comprehension were taught in a structured, sequenced manner until mastery was achieved at each level. Teachers found that in the first few years of the program reading achievement scores increased. By sixth grade however an interesting fact was observed. Although reading scores were high on achievement tests, upon entering junior high, reading levels decreased. In fact, learners actually were found to not be reading. A research group brought in to study the problem found that although learners were scoring high on achievement tests, the tests were only measuring what had actually been taught, i.e. the subskill or component part covered. Learners in fact were spending most of the allotted language arts time completing dittoes or workbook pages related to the subskill, but were spending only a few minutes a day actually reading! Although they had mastered each component skill in isolation they were still not reading for meaning, enjoyment, or information. To wit, the parts did not necessarily add up to the whole; the whole was in fact larger than the parts.

Most elementary and secondary schools take an empiricist perspective in their curriculum planning. Fields are isolated and categorized as if they were really separate entities, e.g. science, math, reading, etc, and then they compete with each other for time in the overall curriculum. Subskills are identified, and sequenced into preplanned curricula. Learners are diagnosed, motivated, reinforced, and posttested. The role of the teacher has become one of technician: diagnose the needs of the learner then present the correct sequence of objectives in the correct instructional mode. Even the teacher gets evaluated. Not only are the students' test scores used to validate what they have learned, but in some circles they are even considered an appropriate measure of the teacher's performance!

The implicit assumptions are obvious: parts add up to wholes and variables can be controlled and isolated given enough information and appropriate measuring tools. To wit, the technology has been too "yang", too assertive, too reminiscent of the science of Bacon, Descartes, and Newton. Little, or no, emphasis is placed on the a priori thought of the child. Instead the focus has been on the teacher's behaviors and the curriculum, on control of the learning situation and the learner. Only one person has been dancing, the teacher.

Maturationism

Definition. The maturationist perspective, on the other hand, takes the stance that the innate program of development is of prime importance. All emphasis is placed on the child. Unfolding and growth are assumed to occur by biological programming.

Maturationism in education. The educator's role is simply to prepare an enriched, developmentally appropriate environment. Gesell, Ilg and Ames, and Rousseau are representatives of this perspective. Rousseau long ago wrote about the flowering of Emile, suggesting that the child is innately good and simply needs an appropriate, kind environment to blossom to his full potential. Similarly the Gesell school suggests testing learners in relation to developmental milestones and only placing them in a school environment when they are ready. Maturation is viewed as innately governed, an unfolding process not to be tampered with. Curriculum planning takes the form of assessing the developmental level of the child and then planning appropriate activities at that level.

Problems. Education viewed from this perspective eventually arrives at a dilemma, aptly described by Eleanor Duckworth (1987) in the title of her article, "Either they know it already and we're too late, or we're too early and they can't learn it anyway." Education dissolves to a game of constant assessment and matching, and leaves the question of how to help learners "get ready" unanswered.

Whereas most elementary and secondary programs have been influenced by a "Newtonian" science, most early childhood programs (as well as many of the past "romantic" and "free" schools) have been entrenched with maturationism. The role of the educator has been to prepare the environment and withdraw, to let learning occur at its own pace through experience and play. In placing full emphasis on the "unfolding" growth of the child, they have utilized a technology too "yin", a view somewhat reminiscent of the early science where the goal was to understand the meaning and significance of natural phenomena, rather than to control them. To wit, the teacher has attempted to understand the natural growth processes of the child, prepared an environment conducive to the dancing child, and then become the audience.

A New Model-- The Dance of Construction

Capra, in *The Turning Point* (1982), uses this new world view of relativity, not only to define technology, but to reflect on society, its institutions, and the rising culture. He states,

> "Many (of today's physicists) actively support a society which is still based on the mechanistic, fragmented world-view, without seeing that science points beyond such a view, toward a oneness of the universe which includes not only our natural environment but also our fellow human beings."

The rise in nuclear armaments and our present economic and medical models are viewed by Capra as residual of a "Newtonian technology". Wholes are dissected, problems with parts are diagnosed, and solutions are proposed with no eye towards the relatedness of the parts, nor the effect of the observer. He continues,

> "The yang, masculine consciousness that dominates our culture has found its fulfillment not only in 'hard' science but also in the 'hard' technology derived from it. This technology is fragmented rather than holistic, bent on manipulation and control rather than cooperation, self-assertive rather than integrative, and suitable for centralized management rather than regional application by individuals and small groups. As a result, this technology has become profoundly antiecological, antisocial, unhealthy, and inhuman. What we need is a redefinition of the nature of technology, a change of its direction, and a reevaluation of its underlying value system. If technology is understood in the broadest sense of the term, as the application of human knowledge to the solution of practical problems, it becomes clear that we have concentrated too much on 'hard' highly complex, resource-intensive technologies and must now shift our attention to the 'soft' technologies of conflict resolution,

social agreements, cooperation, recycling, and redistribution. As Schumacher says in his book Small is Beautiful, we need a 'technology with a human face'."

The new science model suggests a new technology of education, one of an organic/systems approach. A middle ground position is needed, more yin than yang, more yang than yin. If motion and change are essential properties of things and the forces causing the motion are not outside the objects but are an intrinsic property of matter, then learning and behavioral change become understood as self-regulated behavior of the child as she interacts with the environment. The teacher must seek to promote growth. She can be facilitative of this process, but she cannot force it. She must dance with the child, at times in unison, at times creating dissonance. Piaget's proposed mechanism of learning, equilibration, provides an interesting solution.

Biological equilibration.

In order to fully understand equilibration, a discussion of Piaget's early work with snails will be helpful. Piaget's fascination centered around the variability of the snail's adaptation. He studied three separate groups of Limnaea stagnalis (see figure 1): those that live in still, tranquil waters (habitat A), those that live in mildly disturbed waters agitated by waves (habitat B), and those that live in severely disturbed waters agitated by high winds and waves (habitat C). While the shape of the snail in calm

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Place figure 1 here.

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water was elongated, the shape of the snails in the agitated water was globular and curved. Piaget believed that the globular shape was due to the activity of the snails.

> "the animal in the course of its growth attaches itself to its solid support, which dilates the opening. At the same time and even because of this, it draws on the muscle that attaches it to its shell, and this tends to shorten the spine ,i.e. the upper part of the spiral shell" (Gallagher and Reid, pg. 22, 1982).

The interesting aspect that Piaget noticed was that the globular snails of habitat B, when removed and placed in an aquarium (habitat A) had offspring that were elongated! This showed that the change in structure was only a phenotypic change, not a permanent genetic change. In contrast the snails in habitat C, although they looked exactly like the snails in habitat B, showed no change even when they were left in an aquarium for 16 years. In other words, the snails in habitat C were distinctly different, having a different genotype.

From these observations, Piaget proposed a middle ground position between the commonly held theories of Lamarck and Darwin. Lamarck had very early suggested that evolution was a result of the organism's adjustment or accommodation to the environment's pressure. In other words, in order for a species to survive in a changing environment it made progressive structural, genetic changes. For years scientists cut tails off rats in an attempt to produce a genetic strain without tails. This act was fruitless and eventually Lamarck's theory was disproven.

Whereas Lamarck took a radical empiricist view, Darwin placed heavier emphasis on the organism. He proposed that evolution was due to random mutations generated by the organism. Whichever mutations were more suited to the environment would be carried on.

Piaget took the position that behavior drives the evolution of new structures because the development of new behavior, more or less, causes an imbalance in the genome, the regulatory system of the genetic structure and a new adaptation to the environment is constructed. He felt that both Lamarck's and Darwin's theories were too radical. He viewed behavior and the organism as a whole system; the balance between the structure of the organism and the environment were all interrelated and thus indissociable. Any change in a part of the system would result in other changes as behavior balanced the structure of the organism against the characteristics of the environment. Thus Piaget believed that, in the case of the snail, progressive reorganizations, or gradual changes in the response of the genome to the environment and the activity of the organism caused " a genetic assimilation whereby the genome entered into an interaction with the environment. The final result is the process of biological phenocopy: the replacement of an initial phenotype by a genotype presenting the same distinctive characteristics" (Gallagher and Reid, 1982, pg. 22).

Cognitive equilibration

Although Piaget's early work was in the field of biology, most of his life was devoted to studying the genesis of cognitive structures and relating this process to his early work in biology.

Structures. A structure, according to Piaget, is a system with a set of laws that applies to the system as a whole and not only to its elements. Structures are characterized by three properties: wholeness, transformation, and self-regulation.

Wholeness refers to the fact that the system is a whole that may in fact be larger than the sum of its parts. The parts, interacting and related, are indissociable from each other and the whole and thus have no meaning by themselves. Their meaning is derived only in terms of the whole, and in relation to each other.

Transformation explains the relations between the parts, how one part becomes another. It pertains to the rules involved in the changing nature of the parts.

Each structure is also self-regulating, meaning that structures inherently seek self maintenance and closure. No matter what operations we do on the structure we still stay within the system. Piaget points out that no discussion of structures would be intact without a discussion of rhythm.

> "regularities in the non-technical sense of the word which depend upon far simpler structural mechanisms, on rhythmic mechanisms such as pervade biology and human life at every level. Rhythm too is self-regulating, by virtue of symmetries and repetitions. Rhythm, regulation, and operation---these are the three basic mechanisms of self-regulation and self-maintenance" (Piaget, 1970).

The concept of whole numbers illustrates well the notion of structure. When we add two whole numbers together we stay within the system of whole numbers (self-regulation). The numbers themselves have no meaning except in relation to each other (wholeness); 5 has no meaning except as 1 more than 4 or 1 less than 6, etc. And, we have many transformational rules explaining the relation between the parts such as adding 2 to 3 gives 5. Such rules are reversible thus we know with logical necessity that 5 - 3 = 2. We also have rules dealing with associativity and commutativity, thus goals are attainable by alternative, compensatory routes.

Contemporary physics models depict the atom as a structure. Probing into the particulate nature of the atom has shown the parts to be only constructs of the observer, dependent on the interaction with the other constructs. Specifically, the properties of mass depend on the momentum. This dependency is not unidirectional, but compensatory; momentum also depends on the properties of the mass. Thus the atom can only be understood as a continual dance of energy, a structural system where the parts interrelate and take on definitions only in relation to each other. Although the parts are indissociable, transformational rules can be derived to explain the changes occurring within the atom. For example, these rules explain well the process of how a photon becomes a wave and how momentum affects the mass of the particles. The rules, in fact, explain the self-regulatory nature of the atom, its rhythm and operations. As the mass increases the momentum to expand does also but it is complemented by the inward pull of the mass. Thus the particles dance between the poles of expansion and contraction to maintain an optimal balance, a structural system of interwoven parts in rhythmic harmony.

Genesis of structures. Although Piaget was interested in illuminating cognitive structures, he was far more interested in their genesis. He wrote, "The subject exists because, to put it very briefly, the being of structures consists in their coming to be, that is, their being 'under construction'....There is no structure apart from construction" (Piaget, 1970, pg. 140). In essence he believed that the human was a developing organism, not only in a physical, biological sense, but also in a cognitive sense. Because he viewed the organism as a whole system, a structure (such that emotional, cognitive, and physical development were indissociable constructs), he showed that the mechanism promoting change in each of the domains was the same, that of equilibration. Thus not only was it equilibration that brought about the structural changes in the snail in its evolution, but it was also the mechanism that explained cognitive development. In fact, it was believed, by Piaget, to be the mechanism inherent in any transformational, growth process.

He understood equilibration as a dynamic process of self-regulated behavior balancing two intrinsic polar behaviors, assimilation and accommodation. Assimilation is the organization of experience due to one's own logical structures or understandings. It is the individual's self-assertive tendency, a tendency to view the world through one's own constructs in order to preserve one's autonomy as a part within a whole system. Piaget, at times, has called it the "reach beyond the grasp", the search for new knowledge, new territory. The organism attempts to reconstitute previous behaviors to conserve its functioning but every behavior results in an accommodation which is a result of the effects or pressures of the environment. In other words, new experiences, "new territory", sometimes contradict our present understandings making them insufficient, thus we accommodate. Accommodation is comprised of reflective, integrative behavior which serves to change one's own self and explicate the object in order to function with cognitive equilibrium in relation to the object.

An example of cognitive equilibration. One of the tasks used by Piaget to demonstrate equilibration in action utilizes seven discs, placed in a row and connected by chains to each other so that a comparison with discs other than the neighboring ones is impossible. Only the last disc, G, can be removed and compared to each disc in the series (see figure 2). The discs

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Place figure 2 here.

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increase in diameter, but only by an imperceptible amount. Since G can be removed and compared to all the others, however, the perceptual illusion of them being all the same size eventually becomes understood as an impossiibility. James, age 7, approaches the task stating that A is the same as B; B is the same as C; C is the same as D; D is the same as E; E is the same as F; and F is the same as G. When asked to compare G to A, he states that G is the big one and all the others are little ones. Then he proceeds to say that G is the same as F, which is the same as E, which is the same as D, etc. The contradiction (G=A, G is larger than A) in his logic is not apparent to him. His assimilatory scheme is one of relying on perceptual comparisons and measuring part, to part, to part. Eventually the illogic of his prior assimilatory scheme begins to bother him and he makes a few minor accommodations. At first he says that E, F, and G are the big ones and A, B, C, and D are little ones. This accommodation resolves the apparent contradiction that something cannot be big and small at the same time, and thus serves as a new assimilatory scheme; he sets out to determine which are the big ones and which are the small ones. A problem persists, however. Every time he is sure that he has two groups, small ones and big ones, he measures the two adjacent (e.g. D and E in the first attempt) and then thinks that he made a mistake. Maybe A, B, and C are the only little ones. Eventually he is right back where he started, with A the only little one. The insufficiency of this assimilatory scheme becomes apparent and another accommodation finally brings about a stable structural change, one which includes transitivity. He uses G to measure each of the discs and concludes that the only possible solution is that each disc is slightly larger than the one prior to it and that if one were to add the differences of A and B, B and C, C and D, D and E, E and F, and F and G, that amount would equal the amount that G is bigger than A. The cognitive changes exemplified in the thinking of James did not occur in rapid succession, but instead were slow progressive equilibrations with development.

In order to fully understand equilibration, one has to think of it as a dynamic process, not a static equilibrium. Just as matter, when viewed by its particulate nature, is in a constant changing state dancing from mass to waves, so too, the learner. Equilibration is not a linear happening of first assimilation, then conflict, then accommodation. Instead it is a dynamic dance of progressive equilibrations, adaptation and organization, growth and change. As we assert ourselves and our logical constructs on new experiences and information we exhibit yang energy. Our reflective, integrative, accommodative nature is our yin pole. These two poles provide a dynamic interplay which by its own intrinsic nature serves to keep the system in an open, flexible, growth-producing state.

Constructivism

Definition. Philosophically, constructivists assert that we can never know the world in a "true" sense, separate from ourselves and our experiences, because we are an indissociable part of the world we are trying to understand. We can only know it through our present logical framework which transforms, organizes, and interprets our perceptions, and this logic is constructed and evolves through development as we interact with our environment and try to make sense of our experiences. Facts and theories which we hold as truths today, may be disproven tomorrow. To constructivists, cognitive development comes about through the same process as biological development--self-regulation or progressive equilibrations. We are, in a very real sense, "under construction."

Constructivism in education. Understanding learning as a self-regulatory process, equilibrating assimilation and accommodation, suggests that learning is an organic process of construction, rather than a mechanical process of accumulation. In contrast to empiricist/reductionist approaches, learning from a constructivist perspective is not seen as an accumulation of facts and associations. Rather, Piaget has conclusively shown that changes in cognition are made throughout development, producing qualitatively different frameworks of understanding. Although a maturationist also prescribes to such stages, he/she assumes they just unfold automatically. A constructivist takes the position that the child must have experiences hypothesizing and predicting, manipulating objects, posing questions, researching answers, imagining, investigating, and inventing. From this perspective, the teacher cannot ensure children get knowledge by dispensing it; a child-centered curriculum and instructional mode is mandated. The child must construct knowledge. The teacher needs to be a creative mediator in this process.

Communication itself even shows evidence of this interactive dance. A polarity appears to exist between listener and speaker. Recent film analyses (Leonard, 1981) show that every conversation involves a subtle and largely unseen dance in which the detailed sequence of speech patterns is precisely synchronized not only with minute movements of the speaker's body but also with corresponding movements by the listener. Both partners are locked into an intricate sequence of rhythmic movements. The work of Brazelton (1974), Tronick (1975), and Stern (1977), among others, demonstrates this same "rhythmic dance" between baby and caregiver.

From a constructivist perspective, education itself becomes a dance--a dance of interaction between learner and teacher, and learner and object.

Just as mass dances to become energy and energy, mass, so the poles of learner and teacher and learner and object form paradoxical, yet unified, relationships transforming each other. (See Fosnot, 1984 for a delineation of the principles involved in a constructivist approach to the technology of education.) The following observation in a K-2 classroom depicts the dance.

The dance in practice. The teacher grouped several children (ages 5 - 7) around her and brought out a die she had made. Each face had a number on it: 6, 7, 7, 8, 8, 9. Thus one face had a six; two faces had sevens; two faces, eights; and one face, nine. With large one inch graph paper, she and the children colored in squares to represent the faces. This process resulted in a bar graph showing one unit for six, two units for 7, two units for 8, and one unit for 9. Then she placed the die in a small box and asked the children to guess what number would show when she spilled the die onto the table. Around the table they responded, each giving his/her own reasoning for his/her choice. Several children chose their favorite numbers and said they thought it would turn up since it was their favorite. Others guessed randomly. The die was thrown and the face was recorded on a new sheet of large one inch graph paper. Several trials ensued, each one recorded, and each time children were asked for a guess and their reasoning. Several children began to guess 7 or 8, but their reasoning was based on the fact that 7 and 8 were showing up more frequently. After several more trials the teacher simply made the observation that it was interesting that the pattern showing up on the graph was similar to the one that represented the faces of the die. She left the children wondering why that was and then dismissed them for lunch.

Jed, a six year old in the group, looked bothered all through lunch. When he returned to the classroom he asked the teacher for the die and began throwing it again. All of a sudden his face lit up and he went running to the teacher. "Teacher, teacher guess what I just figured out? I know why the sevens and eights kept coming up...There's two of each on the die!"

"Why does that matter?" queried the teacher.

"Well you see each time it falls it could land on this side (top face with a seven) or on this side (bottom face with a seven). There's more chances for a seven than a six or a nine."

"By golly, I think you've got something there!" commented the teacher. Then she quieted the class so that Jed could share his discovery with everyone.

Jed had constructed the beginning notions of probability. Better put, Jed was in the midst of "inventing" probability. The teacher had facilitated self regulatory learning by dancing with him. She had not forced the notion of probability on Jed by explaining the principle, externally motivating him to learn it, and then reinforcing it. Nor did she just sit back and wait for it to be constructed out of his play. Instead, she arranged a situation conducive to cognitive conflict by using a predict consequence approach. Further, she entered into the dance by focusing attention on the similar patterns in the graphs. Most importantly though, she had provided dissonance for cognitive adaptation, and then respected his rhythm, moved to his tempo, and fostered his cognitive compensations.

Final Comments

The dance of education is the dance of growth and development; it's rhythm, the heartbeat. The interactions of learner and teacher, learner and object, form a melody like notes playing off each other: sometimes in harmony, sometimes with a Beethovian discordance of creative tension.

When a dance is evaluated it is viewed as a whole. The dancer is not assessed on how well he/she can piroutte, given scores on each skill and then a total. He/she is evaluated interacting with the music, the other dancers, and the audience. So too, perhaps the only way to assess the child learning is to assess the moment; to look at the processes such as assimilation and accommodation; to study the compensations as they occur in the interactions between teacher, object, and learner; to value their rhythms and melodies. Assessing skills out of context of the learning situation is like evaluating a dancer after the performance, but not during it. In the words of the physicist, Capra (1982),

> "There is motion but there are, ultimately, no moving objects; there is activity but there are no actors; there are no dancers, there is only the dance."

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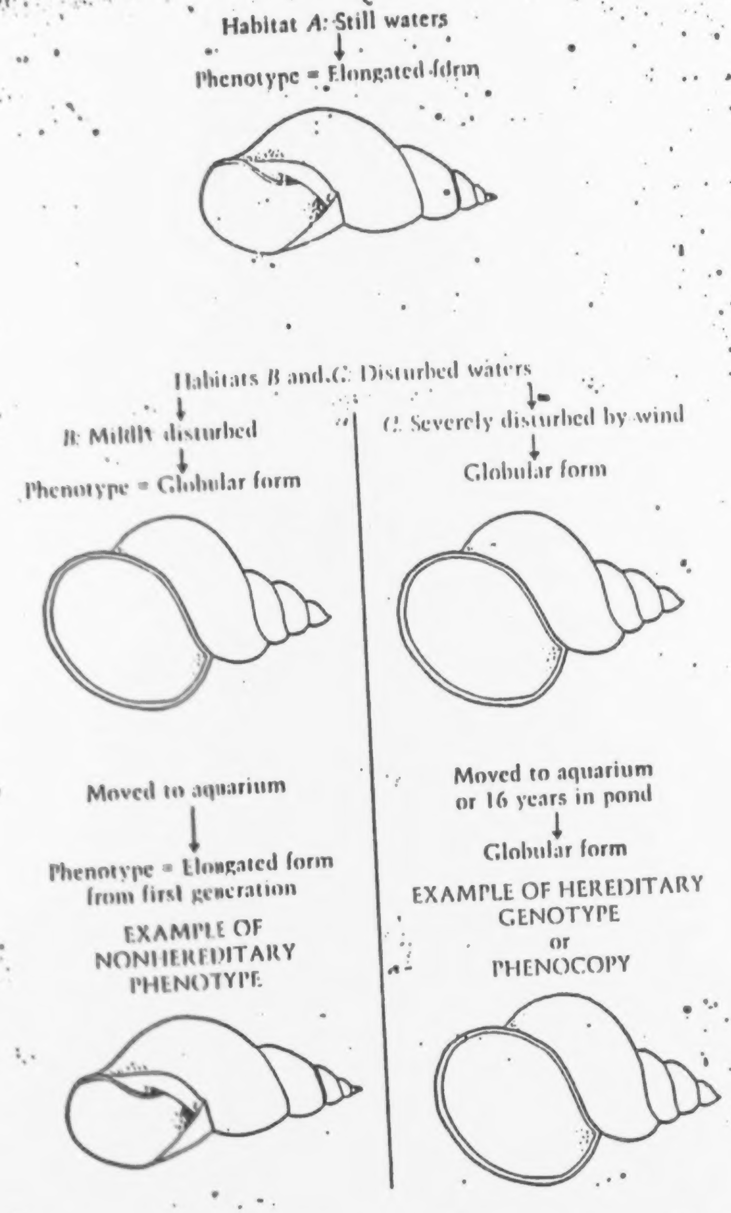
Figure 1



Habitat A: Still waters
Phenotype = Elongated form
Habitats B and C: Disturbed waters
B: Mildly disturbed
Phenotype = Globular form
C: Severely disturbed by wind
Globular form
Moved to aquarium
Phenotype = Elongated form from first generation
EXAMPLE OF NONHEREDITARY PHENOTYPE
Moved to aquarium or 16 years in pond
Globular form
EXAMPLE OF HEREDITARY GENOTYPE or PHENOCOPY

[redacted] Pond snail (*Limnaea stagnalis*) as an example of phenocopy. (Based on Piaget, 1971a, 1974a, 1977a, 1977c.)

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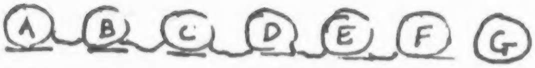
Figure 2

The Disc Problem



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A Paper Presented at the Annual Conference for the
Association for Educational Communications and Technology
New Orleans, LA

January 1988

28.

The Effect of CRT Screen Design on Learning

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Acknowledgement

Though the author is currently at the University of Colorado at Denver, this study was completed at the University of Nebraska with the assistance of a research grant-in-aid and the Maude Hammond Fling Fellowship.

Abstract

Two CAI programs tested the effect of plain and enhanced screen designs with or without information about those designs and task-type on time and learning. The enhanced versions used headings, directive cues, running heads, and graphic devices to organize and structure the content. One program required learners to perform a memorization task, the second required concept acquisition and concept application. The information described the purposes of the enhanced features and instructed the students to use those features while studying. The plain-screen versions were equal to the enhanced versions in learning. Descriptions of text enhancements reduced lesson time when one of the enhancements provided the learner with program control options.

Introduction

Problem Description

The display of instructional text is not solely a function of the author's writing, but also of the publisher's layout design and selected medium, whether that medium is paper or electronic text. In both types of media, text format elements (see Table 1) are combined to create "pages" and "screens" of information. In the case of print media, pages are usually arbitrary points for dividing text, whereas in electronic text, screens serve as logical units of information. The representation of an author's instructional message in the selected medium, though, is not where the problem of design ends, for instructional text has an additional function. Instructional text must encourage an interaction between learner and text; it must facilitate the cognitive processes of reading and leearning. The primary design problem, then, is to identify those combinations of text elements which facilitate specific learning processes.

Manipulations of text elements fall into two general categories: efforts to imitate the effective stimulus and efforts to facilitate the reading and learning cycles with mathemagenic devices or activities (for reviews of this research see Grabinger, 1984; Hartley, 1982, 1985, 1987). Phrase chunking, which focused on making the printed page, or nominal stimulus, mirror the readers' perceived image of the printed page, or effective stimulus, usually had little effect on reading speed or comprehension (Carver, 1978; Pynte and Noizet, 1980). This lack of effect may be due to the undefined and dynamic nature of the effective stimulus, for it is difficult to imitate something that cannot be seen, something that is in a constant state of change, and something that varies from individual to individual. On the other hand, efforts aimed at facilitating the interactive processes of reading and learning through the use of headings, questions, hierarchical paragraph indentation, and directive cues sometimes improved comprehension when those activities were directly related to specific objectives and when the reader was aware of their purposes (Bausell and Jenkins, 1977; Frase and Schwartz, 1979; Hartley, Bartlett, and Branthwaite, 1980; Hartley and Trueman, 1982.)

The main conclusions drawn from these findings suggest that successful design strategies are those that reinforce and facilitate the reading and perceptual cycles. Though generalizations can be reached about the effective uses of some specific elements in defined circumstances, it is difficult to draw conclusions about combinations of the vast majority of less intrusive text elements—elements that do not overtly direct specific cognitive processes.

Discovering the effect of combinations of elements is made difficult by the large number of text elements in operation at one time. To simplify the research problem, a way to categorize those variables was developed (Grabinger, 1984, 1987; Grabinger and Amedeo, 1987). This classification scheme is based on viewers' judgments about screens. Viewers who evaluated model screens composed of a variety of text elements preferred designs that appear organized, structured, and/or simple. Organization refers to designs that have clear-cut segments of text using indentation or graphic organizers such as boxes, windows, or areas of shading or color. Structure is a more refined level of organized text, referring to text designs that indicate a hierarchical and systematic arrangement of subject material utilizing running heads, headings, increased space between paragraphs and, directive cues. Simplicity refers to short, concise, and spacious looking screens.

In other words, it was discovered that the design of the page or screen suggests something about the content of the text on the page. Individual text elements contribute to a "whole" screen or page image and, while individual elements are perceived, it is the overall combination that affects the viewer. The viewer, as a result of that overall combination, makes judgments about the content of the text. The question raised, then, is whether the graphic arrangement of the information does more than suggest something about the content of the text such as, does the arrangement effect how the learner approaches the text, and in turn, learning from the text? An answer to that question may lead to the development of guidelines for designers of electronic text generally and of CAI specifically, guidelines that may point to relationships between text design features and the activation of cognitive processes and learning strategies.

In an effort to answer that question, the aforementioned constructs of structure, organization, and simplicity were used to guide the design of screens in several versions of two CAI programs. Two types of screens were used: plain and enhanced. Plain screens suggested little about the content of the text while the enhanced screens presented structured and organized displays.

In addition to the screen layout two other variables were included in the text design. First, to vary the types of outcomes expected from the learners, two types of tasks, memorization and concept learning, were included in the program designs. It is also recommended that readers be informed of special textual design devices and how to use them (Pace, 1985), so descriptions about the screen designs were included in some of the program versions.

It was predicted that students who used the enhanced screen versions would invest more mental effort in studying the material. Therefore, students using the enhanced version would spend more time with the program and, as a result, score higher on both immediate and delayed retention tests than students using the plain versions.

Method

Subjects

Subjects were 140 fourth grade students from three public schools in Lincoln, Nebraska. The students were predominantly white, lower and middle class with 71 females and 69 males. All students were reading at least on the fourth grade level and had had extensive prior experience with computers in the forms of CAI, Logo, and keyboard operation lessons. Participation was voluntary and dependent upon parental permission.

Program Content

Two programs, **Order** and **Orbit**, were produced in several versions utilizing the **Saber** (1985) authoring system, an MS-DOS based program. Within each program, the content, questions, and learning activities were identical. The versions differed in the design of the screens (see Figure 1) and whether any preliminary information and instructions were provided.

Order required a memorization task and taught the spelling of and the order of the planets from the sun. The lesson material was divided into five parts: 1) a brief introduction describing the purpose of the lesson and, in one of the enhanced versions, a description of the purposes of the text elements on the screen; 2) a pretest to test the ability of the students to spell the planet names correctly; 3) a brief section to drill students in the correct spellings of the planets, if spelling deficiencies were found; 4) a section for learning a mnemonic to help memorize the order of the planets from the sun; and 5) a test on the students' ability to list the planets in the proper order.

Orbit taught the concepts of ellipse and planetary orbit and had four versions. The lesson material was divided into four parts: 1) a brief introduction describing the purpose of the lesson and, in the enhanced versions, the purpose of some of the text elements on the screen; 2) the concept of ellipse was explained using examples, nonexamples, and attribute isolation with text, graphics and, animation; 3) students were tested on their ability to identify ellipses from among other shapes; 4) the concept of ellipse was then used to describe the orbits of the planets and to explain how Neptune, at times, becomes the furthest planet from the sun; and 5) a test of their ability to apply the concepts to the Neptune/Pluto phenomenon completed the program.

The Design of the Screens

Overall Standards. All screens (see Figure 1 for models) were designed to meet "recommended legibility" standards. (Recommended standards are not hard and fast rules, but flexible and derived from research in both printed text and electronic text. The most recent and concise summary is in Hartley, 1987.) Lines of text were double spaced, unjustified, and kept to a maximum width of 40 characters. Indentation was used to reflect subordinating ideas. Responses were always made toward the bottom of the screen. One idea was used per screen.

Plain Versions. The plain versions included text, white on black, without headings, directive cues, graphic organizers, or running heads.

Enhanced Versions. Enhanced screens were designed to appear structured and organized, yet spacious and simple. Each screen in the enhanced versions included at least one heading describing the content of the page, a running head at the top of the page to describe the general content and task required in the section of the program the student was in, and at least one directive cue in the form of color highlighting to emphasize an important word or phrase. Where pertinent, a graphic organizer in the form of a box (see Figure 1) or background color change was used to help organize subtopics. A second running head was added to the bottom of the screen in the **Orbit** versions to summarize the keystroke commands to move back and forth among the screens (this second feature is not seen in examples in Figure 1).

The Information. In **Order 3** the information described the text elements of running head, heading, directive cues, and graphic organizers and explained why they were used. The instructions in the **Orbit 2** and **Orbit 4** described the text elements and informed the students how to use special keys to move back and forth between the screens to review material.

Lesson Versions

Order had three versions (see Figure 2). **Order 1,** was a plain. **Order 2** and **Order 3** were enhanced with the additions of a running head, color, boxes, and lines to make the screens appear more organized and structured. Finally, instructions on the meaning of the various text elements and how to use them to study were included with the third version, **Order 3**.

Orbit had four versions. **Orbit 1** was plain. **Orbit 2** was also plain, but included instructions on how to use specific command keys to review previous screens. The screens in **Orbit 3** were enhanced with the additional text elements. **Orbit 4** included the enhanced screens and added the information about the features of the screen and how to return to previous screens for review.

Orbit had four versions because it included the addition of command key descriptions. **Order** had only three versions because a sophisticated branching design controlled student moves to reviews and practice.

Measurements

Three measurements were used as dependent variables: average time-per-screen, immediate recall tests, and delayed retention tests. The total time spent on the program was divided by the total number of screens seen by the student for the time-per-screen (TimPerScr) variable. TimPerScr was used as an indication of whether the added text elements encouraged the student to spend more time studying, organizing, reflecting, or memorizing the subject material. The tests for the **Order** program were composed of 9 questions requiring the subjects to recall and list the nine planets in order from the sun. The **Orbit** tests were composed of five multiple choice questions asking the subjects to select ellipses from nonexamples and to test their understanding of the Neptune/Pluto phenomenon.

Procedures

Permission to use the public school students limited the time available to an average of 20 minutes per student. The programs were assigned to students in an ordered manner to insure a balance of subjects for each version. Students were assigned to the treatment by the cooperating teachers on a random basis. Students entered the treatment room and sat before an IBM PC with a color monitor. The program was then started. The experimenter pointed out the "ENTER" key, explained its purpose, and monitored the progress of the student. The only assistance offered by the experimenter was to help the student recall the proper key sequence to proceed in the desired manner. No assistance was provided with answering questions asked within the programs. Following completion of the program the students were given a certificate of achievement for participating in the experiment. The delayed retention test (RetTest) was given two weeks later.

Results

Design and Analysis

Since the learning tasks in each program were different, each was analyzed separately. The analysis began with a MANOVA (SPSSx, 1985) to examine the effects of the independent variables of program version, school, and gender with all three dependent variables: TimPerScr, ImTest, and RetTest (see Figure 2). This was followed by a repeated measures ANOVA (BMDP, 1985) of each program version with the dependent variables of ImTest and RetTest. Finally, when necessary, separate one-way ANOVAs were performed to help interpret the repeated measures ANOVA. A predetermined significance level of $p < .05$ was used.

Order

Seventy-eight students from three schools, A, L, and M, used the three **Order** versions. The MANOVA indicated a main effect among schools (Table 2). The follow-up univariate F-test indicated that School L spent significantly more time-per-screen than either schools M or A (Table 3 and Figure 3). The MANOVA reported no differences between gender or among the program versions. The repeated measures analysis showed no difference for main effects between the ImTest and RetTest variables and the program versions, but did indicate an interaction (see Table 4). A one-way ANOVA follow-up (see Table 5 and Figure 4) indicated that students who used **Order 3** (enhanced screens with instructions) scored significantly higher on the delayed retention test (RetTest) than on the immediate computer test (ImTest).

Reliability analyses of the 9-item ImTest and RetTest reported Cronbach Alphas of .83 and .89, respectively.

Orbit

Sixty-two students from two schools, M and A, used the **Orbit** versions. The MANOVA results reported no main effect between the schools, however there was a significant difference among the program versions (see Table 6) in the TimPerScr variable. The univariate F-test follow-up indicated that students using **Orbit 3** (enhanced screens) spent more time-per-screen than students using the other three versions (see Table 7 and Figure 5). There were no differences between gender or among the program versions within the learning variables (ImTest and RetTest).

Reliability analyses of the 5-item ImTest and RetTest reported Cronbach Alphas of .28 and .53, respectively.

Discussion

Though it was predicted that students would spend more time with the programs with enhanced screens, this difference occurred only in two situations. In one case, students using **Orbit 3** spent significantly more time-per-screen than students using the other **Orbit** versions. (**Orbit 3** included a second running head with key command summaries, but did not include information about the text elements.) If the additional time-per-screen was due to the text element design it would be reasonable to expect users of **Orbit 4** (identical to **Orbit 3** with the addition of the text element descriptions) to have spent a similar amount of time-per-screen; however, the users of **Orbit 4** spent the same amount of time as the users of the other **Orbit** versions. It is more likely, then, that the difference is explained by the lack of instructions and text element descriptions in **Orbit 3**. The students using **Orbit 3** were observed to have experimented with the commands at the bottom of the screen to discover the purposes of the commands. Students using **Orbit 4**, on the other hand, needed no time to experiment because the purpose of each command was explained at the beginning of the program. This would be consistent with Hartley's (1987) recommendations that special design features should be explained to readers in advance.

In the second case, students using the **Order** program in school L spent more time-per-screen than students in schools A and M. No differences among the schools were expected since all of the students were reading on at least the fourth grade level. Although no ability-level data was gathered, subsequent conversations with teachers indicated that there may have been ability differences among the schools.

It was also predicted, on the basis of viewer preferences and classifications, that structured screen designs would provide powerful cues to facilitate mental involvement and thus increase learning from the CAI material. However, the lack of instructional effects attributable solely to the arrangement of text elements indicates that graphic changes alone are not enough to increase mental involvement with the text. There are several explanations which may clarify why a learning effect was not found.

First, interventions that directly involve the learner have been more successful in affecting learning. In a study comparing a mathemagenic activity with a text element change, questions were found superior to highlights in aiding the learning of factual items and in aiding performance on higher cognitive operations (Schloss, Sindelar, and Cartwright, 1986). Additional successful interventions (Davey and Kapinus, 1985; Glynn, Britton, and Muth, 1985; Reder, Charney, and Morgan, 1986; Rieber and Hannafin, 1987; Smith and Friend, 1986) have involved elaborative, orienting, or generative activities within the structure of the text, though it is not known whether any special changes were implemented on the design of the instructional materials. These changes are also more mathemagenic than design changes to the page.

A second explanation for the lack of learning effect may lie within the individual differences of the students. It was not possible, under the restrictions governing the participation of the schools, to gather more individual data about the students so, the effects of ability was not examined. In addition, all subjects were between 10 and 11 years old. This may be too young for students to recognize specific text elements and then develop strategies to use those elements, for the development of effective learning strategies is in part related to maturation and experience.

A third reason may be found in the instructional design of the software. The instructional design of both programs proved effective, for there were no differences in ImTest or RetTest scores among the versions of each program. **Order** included a mnemonic in its design, which is a powerful learning strategy (Carlson, Kincaid, and Hodgson, 1976). **Orbit** was a highly visual program with some animation, which probably played to a learning strength of young people (Pavio, 1979).

Finally, the screens for all versions, even the plain versions, were designed to be consistent with publication standards. There was no "ringer" version, a version designed so poorly that students would have had difficulty reading it. One of the possible generalizations, then, is that a simple, legible, clean design is as effective as the more complex and structured designs.

There was one result difficult to explain. There appears to be no apparent reason why **Order 3** would score significantly higher on the RetTest than the ImTest. Since this occurred with only one of seven groups, the difference may be the result of a small cell (24) or unknown intervening variables.

Despite the lack of instructional difference, there are implications for both screen design and future research. First, it appears that, for this age group, simple, spacious screens are as effective as more organized and structured designs. It does not appear that fourth graders infer anything about the content from the arrangement of the text elements on the screen, though the effects of enhanced designs on older age groups still needs to be examined. Second, the addition of unexplained text elements to the screen may prove distracting. Although the addition of a command key summary without a description of its purpose did not interfere with learning in this case, its have a negative affect on efficiency. The effect on undescribed text elements may vary with more complex material and different age groups.

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Table 1

Examples of Text Format Elements

- line length
- type style
- heading location
- type of directive cue
- ink color
- paragraph indication
- running head location
- justification
- character attributes:*
    - reverse video
    - underlining
    - italics
    - line breaks
    - page numbering
- type size
- leading
- use of directive cues
- number of columns
- paper color
- use of graphic devices
- use of headings
- word spacing
- functional areas:**
    - running heads
    - directions
    - student responses
    - error messages
    - feedback to students

(*Isaacs, 1987; **Heines, 1984)

Table 2

MANOVA Results of Differences Among Schools for **Order**

Test	Value	Approx. F	Hypoth. DF	Error DF	Sig.
Pillais	.29611	3.18611	7340.19690	110.0	.006

Table 3

Univariate F-test: Differences Among Schools for **Order**

Variable	SS	Error SS	Hypoth. MS	Error MS	F	Sig.
TimPerScr	.06757	.36264	.03378	.00648	5.21704	.008
ImTest	37.72113	373.81905	18.86056	6.67534	2.82541	.068
RetTest	36.28461	451.70079	18.14231	8.06609	2.24921	.115

Table 4

Repeated Measures ANOVA for **Order** Program

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Prob.
Mean	7340.19690	1	7340.19690	750.18	.0000
Order	2.86386	2	1.43193	.15	.8641
Error	694.70370	71	9.78456		
Main Effect	3.82017	1	3.82017	.83	.3654
2-Way Inter.	32.42773	2	16.21387	3.52	.0348 *
Error	326.86957	71	4.60380		

Table 5

Follow-up ANOVA of Interaction Identified in **Order** Program

Source	Sum of Squares	Degrees of Freedom	Mean Square	F	Tail Prob.
Mean	2523.00000	1	2523.00000	300.67	.0000
Error	193.00000	23	8.39130	.15	.8641
Main Effect	21.33333	1	21.33333	5.94	.0230 *
Error	82.66667	23	3.59420		

Table 6

MANOVA Results of Differences Among **Orbit** Versions

Test	Value	Approx. F	Hypoth. DF	Error DF	Sig.
Pillais	.57965	3.51250	9.00	132.00	.001

Table 7

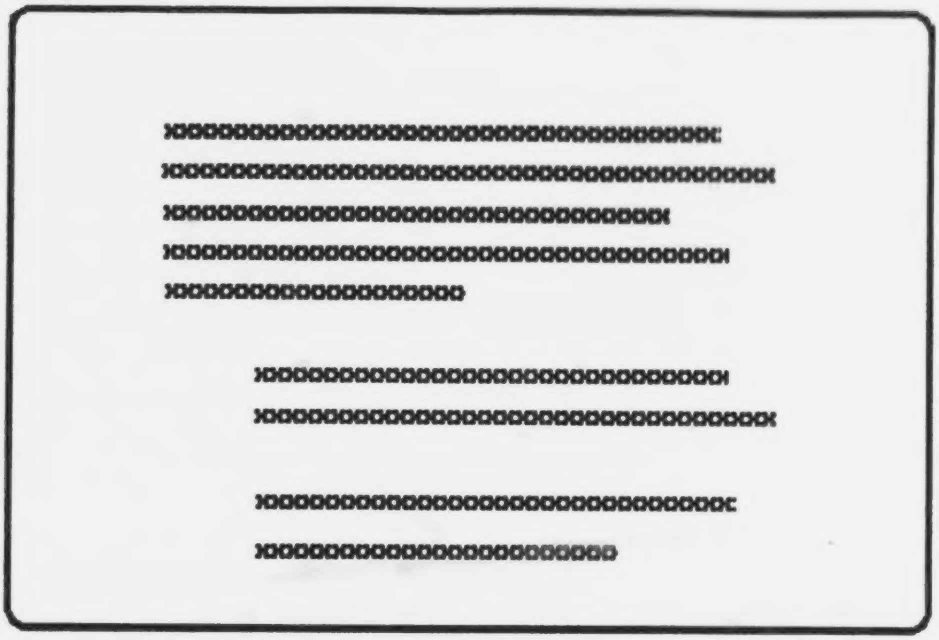
Univariate F-Test: Differences Among **Orbit** Versions

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig.
TimPerScr	.29900	.36767	.09967	.00836	11.92746	.000
ImTest	3.91677	92.38214	1.30559	2.09959	.62183	.605
RetTest	4.27161	29.64762	1.42387	.67381	2.11316	.112

Figure 1

Examples of Screens from the CAI Programs

1a. "Plain Vanilla" Screen



1b. Enhanced Screen

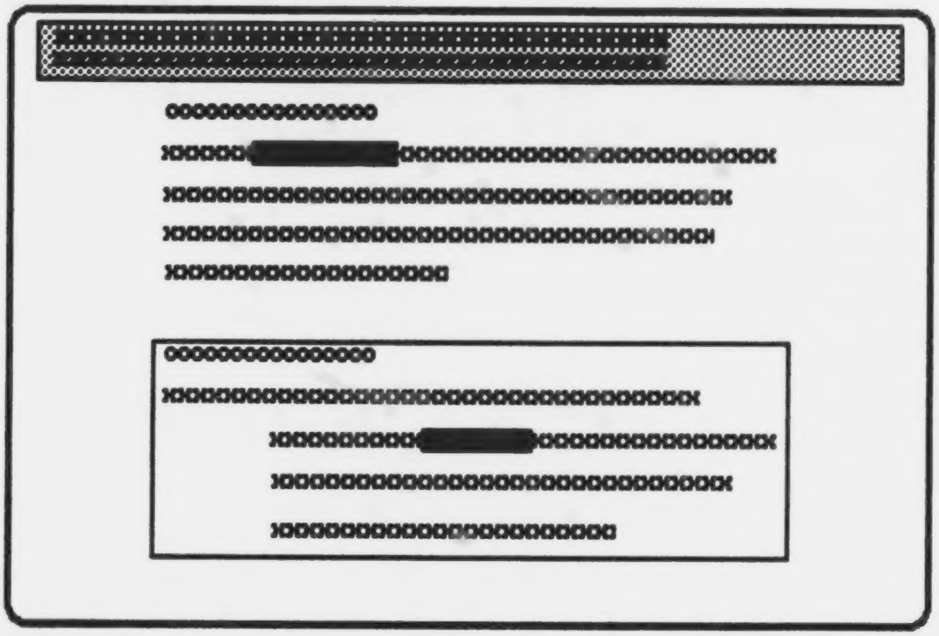


Figure 2

Diagram of Research Analysis

	Order 1	Order 2	Order 3
Imtest			
Rettest			
Timeperscr			

	Orbit 1	Orbit 2	Orbit 3	Orbit 4
Imtest				
Rettest				
Timeperscr				

Figure 3

Observed Means Among Schools For TimPerScr

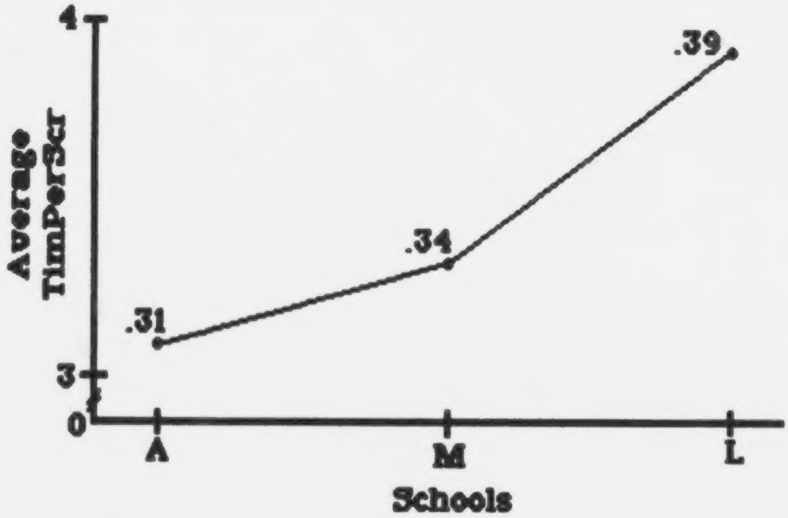


Figure 4

Interaction Program Version and Time of Test for **Order**

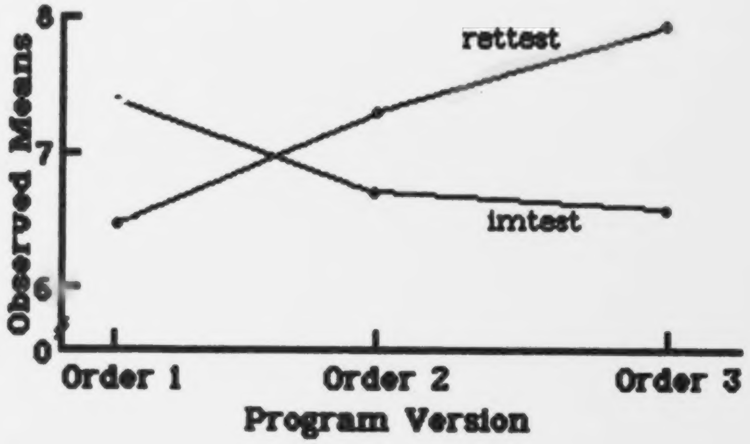
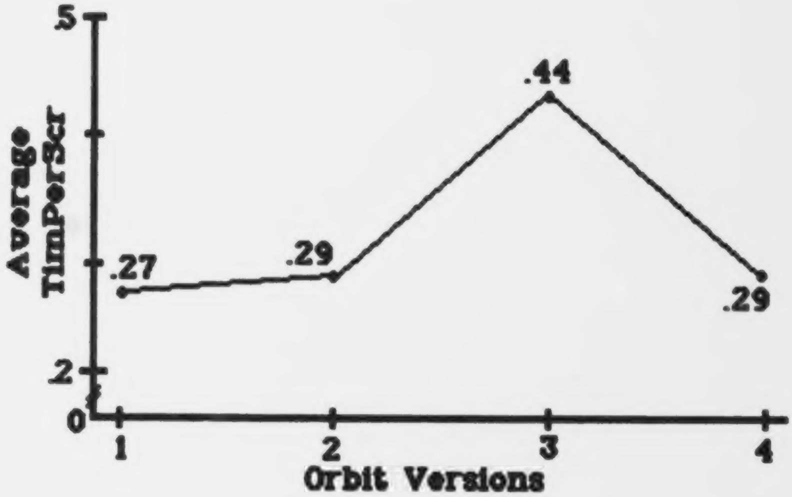


Figure 5

Observed Means for **Orbit** Versions



Title:

Independent Study: Personality, Cognitive, and Descriptive Predictors

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Independent Study:

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A Paper Presented at the Annual Conference for the
Association of Educational Communications and Technology
New Orleans, LA

January 1988

Independent Study: Personality, Cognitive, and Descriptive Predictors

Abstract

This study compared personality, cognitive style, and descriptive preferences of 79 preservice undergraduate education students who chose independent study vs. traditional, teacher-directed study. Self-esteem, field-articulation, locus of control, cognitive style preference, and need for achievement tests were administered and descriptive data regarding GPA, gender, and educational major were collected. A discriminant analysis of test scores indicated that those electing independent study had a high need for achievement, had an internal locus of control, and preferred learning via active experimentation.

Introduction

Independent study instructional designs have been popular over the past two decades. Popular forms of self-paced designs include learning centers, programmed instruction, and the personalized system of instruction (PSI). PSI, or Keller Plan, courses provide self-paced learning through a structured set of learning experiences including quizzes, readings, media materials, assignments, and proctoring. Learners are responsible for scheduling their time and completing the exercises. Independent study systems assume that learners will complete instruction more efficiently and with greater satisfaction because they control the pace of instruction and select from a variety of instructional materials options designed to accommodate individual differences.

Courses that utilize PSI assume that self-paced instruction is good for everyone. Yet, many independent study programs have failed because course designers did not consider that personalities and learning styles of the learners were not consistent with independent study. The demands of self-regulation (pacing, sequencing, and practice of instructional activities) are a radical departure from traditional teacher controlled classes and cause significant anxiety in learners. The institution of a PSI course in instructional technology at the University of Nebraska at Lincoln has met with a high level of dissatisfaction. Although a few students seem to thrive in the program and most passed the course with "A's" and "B's", closing course evaluations indicate that most were frustrated and suffered a great deal of anxiety through the experience. A previous study by Jonassen (1985), initiated under similar circumstances, suggested that such problems may be due to learner characteristics. Jonassen investigated field articulation, cognitive style, self esteem, and achievement factors and found that students choosing the PSI method were field independent, had an internal locus of control, were less influenced by others, and employed more flexible reasoning patterns.

It was observed in the University of Nebraska program that there seemed to be other factors correlated to the decision to follow PSI or traditional coursework, when given the choice. Most students electing the PSI option were female, secondary education students with what appeared to be above average ability. The intent of this study, then, was to examine the relationship among cognitive styles, personality characteristics, and descriptive characteristics of students who elected the PSI mode vs. those who chose the teacher-directed mode.

Method

One hundred thirty nine undergraduate students enrolled in an introductory instructional technology course at the University of Nebraska at Lincoln made up the sample for the study. The students were secondary or elementary education majors and predominantly female (over 60%). During the initial class session, students were administered a selection fo personality and cognitive style instruments listed below. Complete data were compiled for only 79 students, so this group comprised the sample.

Instrumentation

Rosenberg's Self-Esteem Scale (Rosenberg, 1965), is a self-report, 10-item, forced-choice scale designed to assess global self-esteem. The lower the score, the higher an individual rates him/herself.

Rotter's Internal-External Scale (Rotter, 1966) is a 29-item (six fillers), forced-choice test which assesses degree of internality of externality. Larger scores represent higher levels of externality.

Group Embedded Figures Test (Oltman, Raskin, and Witkin, 1971) is a 32-item test to measure field articulation. It was designed to test an individual's ability to locate a previously seen simple figure within a larger complex figure which has been so organized as to obscure or embed the sought-after simple figure. The larger the score, the more able the student is to disembed the figure and thus, the more field independent or analytical the student is.

Kolb Learning Style Inventory (Kolb, 1983) is a 12-item test which assesses a respondent's preferred style of learning. Four scores are generated to assess the degree to which each student prefers to learn via concrete experience (CE), abstract conceptualization (AC), active experimentation (AE), and reflective observation (RO).

Conceptual Styles Inventory (Kagen, Moss, and Siegel, 1963) is a 30-item, graphic test to measure a respondent's predilection to think in a relational or analytical manner. Only Part 1 (15 items) was used.

Need for Achievement Scale (Samuels, 1979) is a 24-item forced choice test to measure need for achievement. Higher scores indicate a greater motive to achieve.

Descriptive Information was collected on individual data sheets. Information collected included GPA, gender, and major.

A *Course Pretest* was administered. The pretest scores were used to determine whether prior knowledge affected the decision to choose PSI or classroom instruction.

PSI Registration Form was used to record each students reason for selecting for the PSI method of study.

Procedure

Following testing, the requirements of the course were explained. Students were given the choice of completing the course requirements by PSI or traditional classroom, teacher-paced instruction. The former consisted of using manuals, quizzes, and media materials for each topic in a specified sequence. The latter method consisted of regularly scheduled class sessions consisting of lecture, demonstration, discussion, and viewing and listening of audiovisual materials. Course requirements and standards were identical for each group. Following the choice of study formats, each group was provided with instructions specific to their mode of study and dismissed.

Of the original 139, 79 (82%) finished all materials and the course. Of the 79, 17 (22%) chose and completed the course in the independent study format. Students' reasons for choosing one format over the other were not considered, only their desire to participate.

Results

A stepwise discriminant analysis of 14 variables was conducted, using Wilk's Lamda and a $F > 1.0$ as entry criterion. A total of 68.35% of the grouped cases were correctly classified by the analysis. Three significant discriminant variables emerged (Table 1). The most significant discriminator was need for achievement. Independent study students had a higher achievement motive. Closely related was the next most significant variable, locus of control, where independent study subjects were more internal and preferred to take more personal control of their own learning. The third significant variable was the active experimentation (AE) dimension of Kolb's learning styles, where the learning strengths of the independent study students lay in their desire to do things, to carry out plans and experiments, to apply new ideas.

Table 1. Stepwise Discrimination Analysis Results

Variable	F	Cumulative Wilk's Lamda
(1) Need for achievement	11.190	.87307
(2) Locus of control	3.980	.95085
(3) Active experimentation	2.972	.96284

Discussion

The analysis supports the contention of Szabo and Feldhusen (1970) that personality variables are useful as predictors of independent study preference. These results and those from Jonassen's (1985) study have identified several basic characteristics that may serve as discriminators between students choosing independent study and those choosing a teacher-directed class. In both studies, locus of control was found to be a significant discriminator. The independent study students possess a high internal locus of control, that is, they choose to be responsible for their own actions and attribute successes and failures to their own ability and effort. Both studies also show that these students have a higher need for achievement, that is, independent study students have a high motive to succeed and work diligently to attain their goals. The "locus of control" and "need for achievement" discriminators correlate closely with Jonassen's (1985) addition findings that independent study students were more self-confident and had a lower need for affiliation.

There was no evidence to suggest that ability or descriptive factors played roles in influencing the independent study decision. Neither GPA nor other intelligence variables (Jonassen, 1985) were significant descriptors. Nor were gender, major, and prior knowledge correlated with the decision.

So, a clear conception of students who select independent study has been confirmed. These students are goal-oriented, more purposive in achieving their goals, and less influenced by peer values and motives. These students are self-reflective, independent, and self-assured. They are willing to take moderate risks, especially if the risks permit them to maintain active control of their learning activities. They believe in their own ability. These interpretations are also supported by the independent study students' own statements, for 59% (12 of 17) of those who elected PSI state that they wished to take more responsibility and have more control over their won learning. (The other five students stated that a scheduling conflict was the primary reason for opting for PSI.)

The implications of these findings are that independent study, within a standard PSI course structure, is a preferred mode of instruction for only a minority of students who are strongly motivated and self-assured. To force other students into a PSI course causes increased anxiety and increased levels of anxiety can impede learning. The inference is clear. The best way to individualize instruction may not be to force all students into a classically structured PSI course. To do so is to ignore their their personality and learning styles. Different kinds of support structures need to be developed and tested for those who have lower achievement and internal control levels. Additional research should also examine the effects of prior experience with independent study and training in using independent study programs. Individualization that does not accommodate to the personality needs of the learners is not truly individualized.

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Title:

Internally Generated Feedback with an Instructional Expert System

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January 1988

Internally Generated Feedback with an Instructional Expert System

Background

The provision of feedback is a major part of instruction. This is especially important in a procedural task, such as the production of instructional materials, where students learn and practice new skills with unknown expectations. Appropriate feedback confirms the learner's expectancy, directs attention to relevant factors, and stimulates recall of relevant skills and knowledge (Gagne, 1977). Generally, research indicates that "appropriate feedback" is precise, frequent, and most valuable immediately following completion of a task (Van Houten, 1980). However, the feedback process is often highly dependent upon the quality of the teacher administering the instructional system.

The impetus for this study arose from the need to provide timely and specific feedback about the quality of a variety of visual materials production techniques (dry mounting, laminating, rubber cement mounting, lettering, and cutting). The provision of appropriate feedback was a persistent problem because minimally qualified teaching assistants (TAs) were used to staff the class lab sessions. The TAs main weaknesses were in the areas of consistency, accuracy, and knowledge of production techniques. Students frequently had to wait long periods for advice on the quality of their skills and projects. There was also a long gap between completion of a project and its evaluation report. While the learning of procedural skills was for the most part successful, there were wide differences in quality and the ability of the students to evaluate their own or others application of the skills.

The purpose, then, of this study was to develop an instructional system that would provide precise and timely feedback. More specifically, the objectives of this project included both basic and applied concerns: first, was the need for a teaching strategy that would facilitate the learning of production skills and their subsequent transfer to an evaluation and self-critiquing task; and second, was the need to develop an instructional system that would efficiently and effectively teach a large number of undergraduates with minimally qualified teaching assistants.

The proposed solution called for an expert system as a central part of a complete instructional system. An expert system seemed a creative and effective because of the likelihood of a change in student processing strategies. It was believed that the expert system would enable the students to use processing strategies not used when receiving feedback from TAs. The TAs, who facilitated learning by offering suggestions and brief critiques of student techniques, did not foster the growth of a schemata appropriate for learning to evaluate productions because their method did not illuminate nor involve the student in using the evaluation criteria. The expert system, on the other hand, offered a method that would illuminate the production criteria by taking learners through questions, choices and decisions in a step-by-step manner. It was expected that the expert system would permit the active manipulation of variables (production criteria) while testing the affects of hypotheses (production practices) would affect learning (Salomon, 1985). Salomon (1985) stated that

> "The more a technique can be designed to activate, model, or short-circuit cognitions hitherto untapped by other means, the greater its opportunity for fostering unique learning effects and for making a difference in learning and development." (p. 210)

In this case, the expert system embedded strategies in the instructional presentation that would encourage the learner to process the information in a systematic and precise way in order to work through the material (Rigney, 1978). In other words, the expert system fostered a more "mindful" (Salomon, 1985) approach to instruction on the part of the learner by directing attention and encouraging a more mentally active role in evaluating their own projects. The expert system also moved the focus of feedback provision from external to internal. The students, in a sense, generated their own feedback rather than having it provided externally from the teaching assistant. Hillman (1970) showed that a group receiving immediate feedback through self-scoring showed considerably more improvement on a standard test than the group receiving 24-hour feedback.

The proposal to use an expert system under such conditions raised several questions. First, could an expert system provide feedback as effectively as a "skilled" instructor? Second, how would the use of an expert system affect the learning of procedural objectives? Third, how would the use of an expert system affect the learning of the ability to apply the production skills to an evaluation task? Finally, what would be the reactions and opinions of students using a "machine" for feedback? The following hypotheses were formed to guide the study:

1. The learning and application of procedural production skills would be equal between a group using the expert system for feedback and a group receiving teacher provided feedback. No difference in procedural skills was expected, despite the feedback system because both groups would be instructed by the same teacher in the same manner and complete the same assignments. Clark (1984, 1985) and Hagler and Knowlton (1987) emphasized that if the message is the same the learning will be the same.

2. A group using an expert system for feedback would provide more detailed evaluations of new projects than a group receiving teacher feedback. The contention is that students using an expert system would receive feedback, but would utilize different processing strategies. If different processing strategies are used, then it is likely that different learning will result. It seemed likely that the expert system users would learn more of the details about the criteria used to evaluate the projects since they would be forced to work through the criterial in detail and this difference would show up on an evaluation task.

3. Expert system users would have a positive attitude about using the system. Several studies (Hess and Tenezakis, 1973; Schurdak, 1967; and Schwartz and Long, 1967) have found that CAI is frequently preferred

by learners, therefore it seemed reasonable to expect that the students would have positive opinions regarding the use of the expert system.

Method

Subjects:

Subjects were 43 undergraduate students from a basic instructional materials production class that was a requirement in the teacher preparation program. Ages ranged from 20 to 40 years of age. There were 25 women and 18 men.

Treatment Groups:

Two treatment groups were used: one group generated itgs own feedback by using an expert system and the other group received feedback from a teacher.

Procedures:

The subjects, though from one class, belonged to two different labs: a morning lab and an afternoon lab. To minimize confounding (Kulik, Kulik, and Cohen, 1980; Clark, 1985; and Hagler and Knowlton, 1987) both groups received the same instruction at the same time from the same teacher.

After attending the morning lecture, the first lab group went directly to a lab session while the afternoon lab left and returned at their appointed time. The treatments were assigned to the lab sections: the morning lab received the expert system feedback treatment and the afternoon lab received the human feedback treatment. Each student performed five production tasks: dry mounting, laminating, rubber cement mounting, lettering, and cutting.

Labs were used as practice and production time. For both groups, the only assistance given by the instructor was in cases of correcting improper or unsafe techniques. When the expert system group had questions regarding the quality of a particular technique or project, they were required to use the expert system for advise. When the teacher-provided feedback group had questions regarding the quality of their work they were answered by the teacher.

One week following completion of the production tasks they evaluated a new sample of each production task. The evaluation task took the form of a written essay whereupon the student wrote as much as they chose about the strengths and weaknesses of each of five project samples.

Expert System Materials:

The expert system was created with an a shell, **Expert Ease** (Human Performance Technolgy, 1984) and used a question and answer approach. Students had to read the questions, analyze their work, make an evaluative judgment, and enter responses to work through the program. The question/response technique was used because questions that require learners to relate textual information to what they already know, to interpret and infer, make the textual material more meaningful and more memorable (Lindner and Rickards, 1985). There was a separate section within the expert system for each production project. Each section was composed of a series of questions based on the criteria (see Figure 1 for a summary of the criteria for each project) used to evaluate each project (see Figure 2 for two screen samples from the expert system program). At the end of each criterion the student was asked to judge whether the project was satisfactory or unsatisfactory with respect to that criterion.

Testing and Measurements:

Each of the five production projects were evaluated on a five point scale. Evaluators used a checklist comprised of the standard criteria for each project. The evaluation task was subjected to two measurements. Within each of the five written project evaluations content analysis was used to count the number of standard criteria cited and of the number of new criteria applied or generated. Opinion measurements included a self-rating of learning, a rating of the expert system.

Results

Table 1 reports the results of the quality of the production projects when compared using a two-tailed t-test (Chase, 1976). Each project was evaluated on a 10 point scale (10 was excellent). Although each project mean for the internally generated feedback group was higher than the corresponding project mean for the externally provided feedback group, the differences were not significant ($p < .05$).

Table 2 reports the t-test results for the number of details that the participants cited from the standard criteria in their written evaluations of sample projects in the evaluation task. The only significant difference ($p < .05$) in the ability of the two groups to evaluate a project was in the evaluation of lettering samples. The internally generated feedback group (2.9333) cited significantly more details than the group receiving external feedback (2.5455).

The second measure of the evaluation task, the number of non-standard criteria generated, showed a significant effect ($p < .05$) for the internally generated feedback group (see Table 3). The internal feedback group generated an average of 1.6 new items for all five evaluation tasks, while the externally provided feedback group provided generated an average of 1.3 new details.

Overall, the opinion measurements of the students who used the expert system to generate their own feedback about their projects were favorable. Table 4 shows that the students believed that the knowledge they gained was essentially the same as the externally provided feedback group. They also believed that the use of the expert system neither improved nor hurt their project evaluation scores. Table 5 presents the summary of results for overall reaction to using the expert system to generate feedback about their projects. Two-thirds of the reactions were at level six or above on the 10-point scale (10 was positive).

Discussion

As predicted, both instructional methods were equally effective in the teaching of the procedural skills used for producing the projects. This result is consistent with Clark's (1984) statements that learning comes from effective instructional design — not from the medium used to deliver the instruction. Note, though, in Table 1, all of the project evaluation means of the internally generated feedback group are higher than the externally provided feedback group. Is this trend due to the novelty effect? Probably not because the use of computers for instruction was not new to the class. Did the students who used the expert system try harder? Again, probably not, because this was the first unit in the first week of a new session — a time when most students are motivated and ready to begin anew. The trend may be due to the positive and specific nature of the questions asked by the expert system. The expert system provided information related to both successes and failures, while the lab assistant usually concentrated on failures of production technique. The expert system provided a means to generated feedback that was non-threatening as well as specific and positive. The feedback generated through the expert system was also timely, students used the expert system either during or after production at a time when corrective feedback is most valuable (Van Houten, 1980).

There were also two indications that internally generated feedback encouraged a different kind of processing and learning. The first indication of this was the significant difference between the two groups on their evaluations of the lettering projects. This may be due to the complexity of the lettering project. The lettering project had seven rather unfamiliar criteria to learn, while each of the four other projects had only five similar criteria (see Figure 1). The step-by-step method of analyzing each criterion with the expert system may have given the participants more memorable practice. The second indication was the ability of the internally generated feedback group to be more creative in their evaluations as represented by their ability to cite more than the standard criteria and to apply criteria from one project to another. This seems to indicate a more thorough learning of all the criteria and their applications.

Finally, the opinions of the students regarding the use of the expert system as part of the instructional program was positive. The expert system was readily available, it was a non-threatening objective evaluation procedure, and permitted the students to take independent responsibility for a major part of their learning process.

It is not the contention here that the reason for the results is the medium — only that an expert system can be an effective part of a well designed instructional system. The results could probably be duplicated with more thorough TA training or student checklists or TA job aids. The computer provides the unique opportunity to demand a response (Avner, Moore, and Smith, 1980) before moving on -- it is a way to prevent short cuts through the designed learning processes. However, the expert system provided an instructional method that placed the responsibility for learning on the student. The internally generated feedback proved as effective as the externally provided feedback for the procedural tasks and better than the external feedback in a declarative task such as evaluation. In other words, the medium was more suited to the objectives for the learner (Allen and Merrill, 1985; Hagler and Knowlton, 1987) in this situation.

The reliance on internally generated feedback with the expert system raises several additional questions. A basic question is whether the expert system that copies or models an expert's reasoning actually teaches the same reasoning process to the users. It would also be interesting to examine the implementation of a more complex expert system, a system that is composed of many questions or that attempts to actually grade a project on a wider scale than pass/fail. The task complexity is also another factor worth investigation. Writing, drawing, or problem solving tasks may also have roles for internally generated feedback.

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Figure 1

Production Criteria for Projects

Lettering

letter spacing
word spacing
line spacing
clarity
straight lines
layout
neatness

Mounting and Laminating

Rubber Cement	Dry Mount	Lamination
stray adhesive	stray adhesive	stray adhesive
bubbles or wrinkles	bubbles or wrinkles	bubbles or wrinkles
straight edges	straight edges	straight edges
layout/margins	layout/margins	layout/margins
neatness	neatness	neatness

Cutting

Name Plate	Easel
sturdiness	sturdiness
straight edges	straight edges
cutting quality	cutting quality
lettering	finishing quality
hinge quality	hinge quality
neatness	neatness

Figure 2

Expert System Shell Sample

Neatness Criterion for the Easel Project

OVERALL NEATNESS:

Neatness is a high priority for all projects.
It is a prerequisite, meaning that this criterion
must be met before any others will be considered.

PENCIL MARKS:	When marking the boundaries of your easel use as few pencil marks as possible. And, make the marks as light as possible for easy erasure. There should be NO visible pencil marks on the easel.
ERASURES:	If you need to erase pencil marks make sure that there are no erasures left on the easel.
MISCELLANEOUS MARKS:	Avoid grease, coffee stains, and any other material that may make your easel look sloppy.

1) "SATISFACTORY" means that you have a neat, clean and professional appearing product.

2) "UNSATISFACTORY" means that you have one or more of the problems described above.

Sturdiness Criterion for Easel Project

STURDINESS:

The easel should be sturdy and solid. If the easel bends or "bows" as it sits up it is not sturdy enough. Generally, you should not use poster board, which is a bit thin for easels, especially those taller than three inches. You can solve this problem by dry mounting two pieces of poster board together to make a thicker and stronger piece of material from which to cut the easel, or by using corrugated cardboard.

1) "SATISFACTORY" means that you have a neat, clean and professional appearing product.

2) "UNSATISFACTORY" means that you have one or more of the problems described above.

Table 1

Project Scores

	Expert System	Teacher	Signif.
Lamination	7.9048	7.3478	.603
Rubber Cement	7.3333	6.9130	.700
Dry Mount	7.9524	7.6087	.187
Cut	7.1905	6.5652	.146
Lettering	7.1905	6.7391	.372
Overall Score	7.5143	7.0348	.672

Table 2

Number of Details Cited in Evaluation Task

	Expert System	Teacher	Signif.
Lamination	3.5333	3.0455	.618
Rubber Cement	2.8000	2.1818	.779
Dry Mount	2.4667	2.5909	.740
Cut	2.5333	2.5909	.301
Lettering	2.9333	2.5455	.028*

Table 3

Extra Details Mentioned on Written Evaluation Task

	Expert System	Teacher	Signif.
Total No. Extra	1.6000	1.3043	.015*

Table 4

Descriptive Summaries

	More	Same	Less
Amount of Learning	5	16	0
	Better	Same	Bad
Affect on Project Score	4	15	2

Table 5

Overall Reaction to Expert System

negative	0	1	2	3	4	5	6	7	8	9	10	pos.
Reaction	1				2	3	4	5	4	2		
Percent	5				9.5	14	19	24	19	9.5		

Title:

Effects of New Computer Technology on Increases in Children's Word Recognition Automaticity

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Running head: WORD RECOGNITION AUTOMATICITY

Abstract

This study compared the effectiveness of two computer based techniques for improving word recognition automaticity in children with mild reading difficulties. One of the techniques provided practice in identifying individual words out of context, while the other technique, referred to as repeated reading, provided practice reading specific words in context. Third and fourth graders with reading skills at approximately the 18th percentile were used as subjects. All children experienced practice using both techniques applied to different sets of words. The repeated reading technique was more effective than the context-free method in increasing the number of words in children's sight vocabularies under both context-free, and within-context assessment. The repeated reading technique also required less time per word to reach a specific mastery criteria, and thus was a more efficient instructional method.

Effects of New Computer Technology on Increases in Children's Word Recognition Automaticity

The ability to recognize whole words both rapidly and accurately is critical to the acquisition of beginning reading skills. Hence, a great deal of instruction for beginning, moderately delayed, and disabled readers is focused on increasing the speed and accuracy, or automaticity, with which students can recognize individual words. "Word recognition automaticity" is defined as the rapid and accurate processing of whole words as units, rather than the use of word attack skills to sound words out for identification. Individual words that are recognized automatically, regardless of whether they are encountered in text or in isolation are referred to as part of a reader's "sight word vocabulary." Consequently, to increase the number of words in a reader's sight word vocabulary, individual words must be recognized to a level of automaticity that includes criteria in both speed and accuracy.

This study examined two different computer based methods for increasing word recognition automaticity in young children with mild reading difficulties. It is responsive to the broadly accepted finding (Stanovich, 1986) that the primary reading difficulty of many poor readers lies at the word, rather than the text, level of processing. That is, the reading progress of many children in the early elementary grades is seriously limited by their inability to acquire skills in the rapid and accurate identification of words. Both theory and data suggest that difficulties in acquiring efficient word reading skills can be a primary cause of inability to comprehend the meaning of written material (Breznitz, 1987, Lesgold & Resnick, 1982; Perfetti, 1985).

When young children read individual words, they utilize at least three different methods for word recognition. Perfetti (1984) refers to these methods as involving different representational, or coding systems. Some words, for example are recognized as whole units. "Word identification occurs for these words when a string of visually encoded letters triggers the word representation constructed from frequent encounters with the word" (p.52). Other words are recognized because they contain specific letter strings or groups. These letter patterns have acquired a representational status because they occur frequently in many different words. A third level of representation involves grapheme-phoneme correspondences. Words can be identified by approximating their spoken sound through analysis of sounds represented by individual letters and letter groups.

In his model, Perfetti (1984) suggests that children learn all three representational systems (whole words, high frequency letter groups, grapheme-phoneme relationships) simultaneously, and that they can provide useful support to one another in the acquisition of fluent word identification skills. In our research, we focus on methods to increase the number of words that children can recognize as whole units. This type of recognition usually requires less time than the other, more analytic methods of word recognition, and thus it is one way to help improve the reading speed of children who are experiencing difficulty in acquiring fluent reading skills.

Both of the methods for increasing word reading efficiency evaluated in this experiment utilize newly developed micro-computer technology to assist in presentation of instructional material and evaluation of responses. Although both of the techniques can be implemented using more standard materials, computer presentation greatly facilitates the measurement of response speed, which is a crucial variable in determining mastery of individual words.

One of the techniques involves context-free practice on word lists. This technique is used widely by teachers to increase the sight vocabulary of young children. It is essentially a form of pared-associate learning, in which children are shown individual words one at a time and must learn to respond quickly with appropriate pronunciation. Typically, word lists are practiced repeatedly, with the goal of producing rapid and accurate identification of words on the list.

The other technique we evaluated involves the repeated oral reading of short passages containing words that the children are to learn. This technique has been shown to produce generalized increases in reading fluency in disabled readers (Moyer, 1982), and there is evidence suggesting that it primarily affects the speed with which individual words are recognized (Rashotte & Torgesen, 1985). By repeatedly reading the same passage over and over, children acquire sufficient experience with individual words to allow development of the ability to respond to many of the words as whole word units.

Although both of these techniques have been evaluated positively in previous research, we are aware of no studies that contrast their effectiveness with one another. Given the proliferation of computer based techniques for increasing reading skills, it is becoming increasingly important to understand, not only whether a technique is effective or not, but also about the relative efficacy of different techniques developed for the same purpose. In this study, we examine the relative effectiveness of both techniques to increase the sight word vocabulary of mildly impaired readers. Our dependent measures include: 1) short-term improvements in context-free word recognition speed; 2) long-term improvements in both within-context and out of context recognition speed; and 3) instructional time to achieve mastery as measured by a context-free diagnostic progress test.

Method

Subjects

Subjects were 16 third and fourth grade students attending an elementary school serving a population of mixed SES. The students were identified as moderately delayed readers by their classroom teachers. Their mean overall reading scores on the Comprehensive Assessment Program: Achievement Series (1985) was at the 18th percentile. The students were randomly assigned to two groups of equal size.

Assessment and Instructional Methods and Procedures

Sets of materials were developed by the principal investigator for both testing and instructional conditions. The assessment materials will be described first, followed by those used in instruction.

Word recognition screening test. A list of words introduced in the basal reader series during fourth grade was obtained from teachers. These words were divided into lists of 20 words and presented one at a time on the computer to each subject. The words were presented in lower case text, and students were instructed to respond as rapidly as possible. The examiner pressed a key immediately following an accurate pronunciation of a word. The computer recorded elapsed time between the appearance of a word and the button press indicating a correct response. After a correct response, or after five seconds had elapsed, the word disappeared and a new word appeared.

Analysis of responses to the screening test resulted in a list of eighty words, none of which were part of the sight vocabulary of any of the subjects. A word was defined as part of a student's sight vocabulary if it was pronounced correctly in under three seconds. Although this criteria may seem a bit slow for recognition of sight words, response times in this study included the time it took for the examiner to recognize a correct response and push he timing button. Thus, response times are approximately .6-.8 seconds slower than they would have been with a more direct measurement technology. This delay in response measurement occurs consistently in all conditions of the study, so the basic comparative purposes are not compromised.

The 80 words were first stratified by parts of speech, and then randomly assigned to two sets. The first set consisted of sixty to-be-taught (target) words, and the second set consisted of twenty no treatment control words (non-target words) for which no instruction would be provided. The sixty target words were randomly assigned to four sets of fifteen words. Each set was then randomly assigned to one of four instructional weeks. The twenty non-target words were randomly assigned to four sets of five words. Each set was then randomly assigned to one of the four instructional weeks.

Diagnostic progress test. A diagnostic progress test was prepared for each of the four target word sets. The fifteen target words were presented once, in random sequence. The diagnostic progress test was administered during the instructional sessions in order to determine if words in a given practice set had been mastered. Again, mastery was defined as being able to pronounce a word accurately within three seconds. The testing format was identical to the format of the word recognition screening test.

Immediate context-free posttest. Four immediate context-free posttests were prepared. Each test consisted of a set of fifteen target words and a set of five non-target words presented once, in random sequence. These tests were administered on the Monday immediately following a week of practice for a given wordset. The testing format was identical to the format of the word recognition screening test.

Delayed context-free posttest. The delayed context-free posttest contained the sixty target words, and the twenty non-target words presented once, in random sequence. To prepare the test, 15 target words and 5 non-target words were randomly assigned to four sets of twenty words. This test was given three weeks following the conclusion of all training. The testing format was identical to the format of the word recognition screening test.

Delayed in-context posttest. the delayed in-context posttest consisted of the sixty target words and the twenty non-target words presented once, in four novel stories. To construct the test, 15 target words and 5 non-target words were randomly assigned to four sets of twenty words. Then, four unique stories were developed, each containing a set of target and non-target words. The number of words in the stories ranged from 176 to 192, with an average length of 183 words. Mean readability of the stories was at the third grade level (Fry, 1968). Stories were presented in upper and lower case letters on the computer screen.

The students were instructed to read each story aloud once. They were told to read as fast as they could, without making any errors. They were informed that they would receive no help on difficult words. If they were unable to recognize a word within five seconds, the students were instructed to skip over the word and continue reading when they heard the examiner articulate the cue, "go on." All readings were taped for later analysis. A word was counted as part of a student's sight vocabulary if it was pronounced accurately within three seconds after the preceding word had been articulated, or if it was pronounced accurately within three seconds after the cue "go on" was heard. This test was given at the same time as the delayed context-free posttest. Half the subjects received this test first, while the other half was tested in the opposite order.

Repeated reading instructional materials. A set of stories, each consisting of three unique stories, was developed for each week of instruction. Each story contained the fifteen words in a target set presented once. The number of words in the stories ranged from 165 to 192, with an average length of 170 words. Mean readability of the stories was at the third grade level (Fry, 1968). Four multiple choice questions with three answer possibilities were prepared for each story. The questions referenced facts stated in the story; however, none of the questions nor answers included target words.

All stories were presented via the repeated reading shell of the Lessonmaster Authoring System (Brezin & Wager, 1987). This shell can present customized material in easy to read, upper and lower case text, for multiple presentations.

The students were instructed to read the stories aloud four times. They wee told that all reading errors would be corrected during the first two readings. The experimenter or assistant listened, but did not offer corrections during the final two readings. Immediately following each reading of a story, a unique multiple choice question was presented. Students received immediate feedback concerning the speed with which they read the story and the accuracy of their response to the comprehension question. Following the four repetitions, they received graphic feedback, in the form of a bar graph that showed how fast they read each repetition of the story.

The students were allowed to play a computer dart game following the fourth reading of a story. They were told that they would earn extra playing time for correct answers and for faster reading speeds.

Students practiced a given set of target words with the repeated reading technique for four 20 minute sessions, or until they reached a specified criterion of performance on the target words (all the words correctly pronounced within three seconds). Once this criterion was met, practice continued for the present session, but the student did not have to return again that week. The diagnostic progress test was given immediately following the completion of four repetitions of each story. Thus, if after practicing the words by reading story 1 four times, the child accurately read all the target words within three seconds, performance criterion for the repeated reading condition had been met. If the criterion was not met following the fourth reading of stories 2 or 3, and four practice days had not elapsed, students continued to practice the target words with the repeated reading technique by rereading stories 1, 2, and 3. Practice on a given word set was discontinued after four 20 minute sessions, if mastery was not achieved.

Context-free condition. Three sets of context-free lessons were developed for each week of instruction. Each lesson contained all of the words in a given target set, and consisted of a series of multiple choice items. The lessons were developed using the Matching Shell of the Lessonmaster Authoring System (Brezin & Wager, 1987). The format selected from this shell involved the auditory presentation of a word, and a sentence using the word, via digitized speech followed by the visual presentation of three words in lower case text. The child's task was to choose the word pronounced by the computer. To respond to an item, a student first pressed a number on the keyboard that moved a box to surround the selected word, and then pressed another key to complete the response. Immediate feedback was provided following each response. For incorrect responses, and for responses not completed within five seconds, the box automatically moved to surround the target word. Distractor words appeared similar to the target word to discourage guessing based on first letter consonant sounds, and number of syllables heard. The three practice lessons in a set differed only on the words used as foils in the multiple choice items.

After a student had responded to all of the items in a lesson, a chart appeared on the screen. It displayed the number of correct responses, incorrect responses, no responses, and the average number of seconds taken for correct responses. After responding to each item in a lesson four times, the student pressed a key to access the computer dart game. As in the repeated reading condition, the students were told that they would receive extra playing time for correct and for rapid responses. Following the dart game, students were administered the diagnostic progress test. Subsequent practice in the context free condition was administered following the same mastery rules as used in the repeated reading condition.

Experimental design and procedure

This study employed a within group, repeated measures design. The design was counterbalanced to ensure that all students received opportunity for equivalent intervals of instruction under both instructional conditions. All instruction and practice was provided in a computer lab setting using Apple II series microcomputers. For the first week, group 1 received repeated reading instruction on word set A, and group 2 received context-free instruction on word set A. Following instruction, the immediate, context-free posttest was administered to both groups consisting of word set A and non-treatment word set E. During the second week, group 1 received context-free instruction on word set B, and group 2 received repeated reading instruction on word set B. Following instruction, a context-free posttest was administered to both groups consisting of word set B and non-treatment word set F. This procedure was repeated for a total of four weeks, with the groups rotating until both groups had experienced each instructional condition twice. The delayed posttests were administered to all subjects three weeks after the last instructional week. A diagram of the experimental design can be seen in Table 1.

Insert Table 1 about here

Reliability of dependent measures

The inter-rater reliability for the number of words accurately pronounced within three seconds was determined by comparing the accuracy and speed measurements of two judges on twenty five percent of the total responses. Reliability was computed by dividing the number of agreements by the total number of agreements and disagreements. Reliability for the context-free testing format was 98.5%, while that for the in-context format was 98.7%.

Results

Although the non-treatment words were included in the posttests, they were not included in the statistical analyses. The basic purpose of the experiment was not to determine whether the instructional techniques were effective by themselves, but rather to answer questions about their relative effectiveness compared to each other. The non-treatment words are useful primarily to estimate the effects that experiences outside the experiment might have had on children's ability to read the words included in the practice sets. The Geisser-Greenhouse (negatively biased) conservative degrees of freedom were used in all tests of significance. This test adjusts for the fact that, in some cases, our data did not meet the requirements of compound symmetry and homogeneity of variance (Winer, 1971).

Table 2 presents the means and standard deviations for percentage of words in sight vocabulary, and actual speed of response for words in sight vocabulary, for each of the instructional conditions. It is important to remember that all 16 subjects contributed data to each cell of this table. That is, the data in each cell represent the mean of each subject's performance for two weeks of instruction in each condition. The descriptive data for non-treatment words is included for comparison.

Insert Table 2 about here

A 2 (instructional condition) x 3 (testing condition) ANOVA with repeated measures on both factors was conducted on the percentage of words in sight vocabulary under the three posttest conditions. The analysis indicated significant main effects of instructional condition _F_ (1,15) = 20.84, p <.01, and testing condition _F_ (2, 30) = 34.02, p <.01. In addition, there was a significant interaction between instructional condition and testing condition F (2, 30) = 4.88, $p < .05$. Tests of simple main effects showed that there were significant differences ($p < .01$) between instructional conditions at all testing points, although the differences were smaller on the delayed, in-context measure than the other two posttests. The results indicate that the repeated reading technique was more effective than the context-free instructional method in increasing the number of words in the sight vocabulary of mildly reading disabled children.

The speed data indicate that, for words in sight vocabulary, both methods led to equivalent speed of responding. Visual comparison of data from the treatment conditions with the no-treatment words shows that subjects maintained relatively low levels of responding to unpracticed words in both context-free testing conditions. The relatively higher response values in the in-context testing condition indicate the degree of support for individual word reading provided by the context of the stories within which they were imbedded. This, of course, helps to explain the better performance in this testing conditions for words taught in both instructional conditions.

A second analysis was conducted to determine if the instructional condition under which words were taught differentially affected performance on posttests requiring in-context and context-free word recognition. A 2 (instructional condition) x 2 (testing condition) ANOVA was conducted using just the delayed in-context, and delayed context-free tests. The main effects of instructional condition F (1,15) = 16.22, $p < .01$, and testing condition F (1,15) = 42.61, $p < .01$ were significant; however, there was no significant interaction between instructional condition and testing condition F (1,15) = 2.12, $p > .10$. The failure to find an interaction suggests that the condition under which a word was taught (in context or out of context) did not differentially affect the probability that it would be part of a child's sight vocabulary under the two different (in-context or context-free) testing conditions.

A third analysis was conducted to determine if the two instructional techniques were differentially effective in producing learning that maintained its effects over a relatively long retention interval. A 2 (instructional condition) x 2 (testing condition) ANOVA with repeated measures was conducted on the percentage of words in sight vocabulary on the context-free (immediate and delayed) posttests. The main effects of instructional condition F (1,15) = 21.15, $p < .01$, and testing condition F (1,15) = 36.53, $p < .01$ were significant; however, there was no significant interaction between instructional condition and testing condition F (1,15) = 2.38, p >.10. Thus, both techniques produced learning that was equally resistant to decay over time.

In order to answer questions about the relative efficiency of the two techniques in producing increases in sight vocabulary, we analyzed the results of the first administration of the diagnostic progress test. The first administration of the test was used in order to standardize measures across the two instructional treatments. That is, all students were given the test at least once for each of the four target word sets; however, some students did not have the opportunity to take more than one diagnostic progress test for a given set.

Two separate time to master measures were used. The first, "actual time," included the total time to use the lessons prior to attainment of mastery. The second, "adjusted time," excluded all noninstructional time (time to change discs, time for program to execute, etc.). The actual time measure evaluated the efficiency of the computer programs, and the adjusted time evaluated the efficiency of the instructional techniques.

The average number of minutes a student spent practicing a given target word prior to mastering the word was calculated for each student in each instructional condition, for both actual and adjusted time. To derive the "minutes per word" measures, both the actual and the adjusted time spent to master the words in a given 15 word target set were divided by the number of words mastered. Table 3 depicts the means and the standard deviations of the minutes per word measures for both actual and adjusted time.

Insert Table 3 about here

Two separate one way ANOVAs with repeated measures were conducted. The first analysis was performed on the minutes of practice to master a word for actual time, F (1,15) = 7.51, p <.01, and the second was performed on the average minutes of practice to master a word for adjusted time F (1,16) = 6.12, p <.05. The results of both analyses suggest that the repeated reading technique was more efficient, in terms of the time required to move words into a child's sight vocabulary, than the context-free method.

Discussion

On the basis of this study, our conclusion is that the repeated reading technique is more effective than context-free word practice in improving the sight vocabulary of mildly handicapped readers. Of course, this conclusion is tied in important ways to the two particular computer programs that were used to implement each technique. The major evidence for our conclusion is that the repeated reading technique produced a higher percentage of words in sight vocabulary under all testing conditions, and that it required less instructional time to achieve mastery over each word.

At least two aspects of these findings require additional comment. First, it was mildly surprising to find that method of instruction did not differentially effect level of performance under two different methods of assessment. That is, words learned under context-free instruction were not more easily read in the context-free testing condition, nor did repeated reading instruction have a specially large impact on words tested in the in-context condition. Since the only cues for word recognition provided in the context-free testing condition are those in the graphic word representation, it appears that children were learning to respond to these cues while they read the words in context in the repeated reading condition. This finding is important, because it suggests that the repeated reading technique can produce generalized increases in text processing fluency at least partially because it enables children to respond more rapidly to the graphic cues contained in individual words. These words will then be read more rapidly and accurately, regardless of the context in which they appear.

Our second point of discussion involves the question of the relative efficiency of the two techniques in producing mastery. The answer to this question, of course, depends to a large extent on the way each technique is implemented in its specific computer program. As it turned out in this study, the context-free technique simply required more time to execute many of its operations than did the repeated reading technique. Although careful procedures were employed to deduct noninstructional time from the actual time spent using the lessons for both conditions, the adjusted times for the two instructional techniques may not be equivalent. That is, the adjusted time in the context-free technique may not be representative of all context-free techniques, such as the use of flashcards by teachers. The question of relative efficiency might be answered differently if a different computer program had been used to present the context-free method.

The point remains, however, that even though the repeated reading technique required children to read stories containing many words in addition to the target words, it was still a relatively efficient way to improve children's sight vocabulary. Because this technique may also provide experience that improves general text-processing and comprehension skills (Moyer, 1982), it seems a very promising method to help children increase the fluency of their reading. A major constraint on the use of the technique, however, is that children must have sufficient reading skill in order to read and comprehend connected text before it can be used effectively.

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Table 1

Diagram of Experimental Design

Week Number	Group 1	Group 2
1	Repeated reading, Word set A	Context-free, Word set A
	Immediate posttest, Word sets A and E	Immediate posttest, Word sets A and E
2	Context-free, Word set B	Repeated reading, Word set B
	Immediate posttest, Word sets B and F	Immediate posttest, Word sets B and F
3	Repeated reading, Word set C	Context-free, Word set C
	Immediate posttest, Word sets C and G	Immediate posttest, Word sets C and G
4	Context-free, Word set D	Repeated reading, Word set D
	Immediate posttest, Word sets D and H	Immediate posttest, Word sets D and H
7	Delayed posttests, Word sets A - H	Delayed posttests, Word sets A - H

NOTE: Wordsets A - D consist of to-be-taught words, and wordsets E - H consist of non-treatment words.

Table 2

Percentage of Words in Sight Vocabulary and Speed of Response as a Function of Instructional and Posttest Conditions

		Posttest Condition		
Instructional Condition		Immediate Context-Free	Delayed In-Context	Delayed Context-Free
Repeated Reading				
Percentage of words	X	88	88	62
	SD	18	14	29
Speed of response	X	1.9	1.0	2.1
	SD	.44	.46	.44
Context-Free				
Percentage of words	X	61	74	41
	SD	33	25	32
Speed of response	X	1.9	1.1	2.1
	SD	.45	.56	.43
Non-Treatment Control Condition				
Percentage of words	X	09	52	10
	SD	16	24	16
Speed of response	X	2.3	1.3	2.2
	SD	.45	.57	.45

Note: Speed of response reported in seconds

Table 3

Actual and Adjusted Time to Master a Word in Both Instructional Conditions

Instructional Condition		Minutes per Word, Actual Time	Minutes per Word, Adjusted Time
Repeated Reading	X	3.36	2.77
	SD	3.08	2.64
Context-Free	X	12.57	8.07
	SD	15.89	10.59

Title:

Applications of Artificial Intelligence to Information Search and Retrieval: The Development and Testing of an Intelligent Technical Information System

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Applications of Artificial Intelligence to Information Search and Retrieval: The Development and Testing of an Intelligent Technical Information System

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A paper presented at the annual conference of the

Association for Educational Communications and Technology

New Orleans, Louisiana

19 January, 1988

Abstract

Problems associated with computer-based information access as currently practiced include the sheer volume of information available, the rapidly changing nature of that information, and the difficulty individuals face in attempting to evaluate all knowledge relevant to a particular problem. The increasing availability of large data bases on optical disc has exacerbated the problem, since search and retrieval technology has not kept pace with advances in data capacity. Intelligent data bases, which attempt to combine techniques used in artificial intelligence for knowledge representation and the development of knowledge-based systems with the highly refined data base techniques already developed to store large amounts of carefully structured and organized data, provide a potential solution to the problem of information overload faced by professionals in all fields.

This paper describes the evolution and development of one information system, the knowledge base for steel structures being developed as part of the Technical Information Center for Steel Structures (TICSS) at Lehigh University's Center for Advanced Technology for Large Structural Systems (ATLSS), which is funded by the National Science Foundation. The paper discusses the initial development of the Technical Information Center and reviews the decisions on hardware and software made in the first year as the project goals were refined, particularly the selection of Turbo Prolog as the programming language. The computer-based bibliographic data base designed during the first year of the project and now under development is described, and lessons gained from the experience and their impact on the future direction of the project are discussed. Projected future activities -- including testing of the bibliographic system, expansion of that system into a complete knowledge based system, and the conversion of the system to optical disc (CD/ROM) storage format -- and potential research questions associated with developing and using "intelligent" information systems are also discussed.

Applications of Artificial Intelligence to Information Search and Retrieval: The Development and Testing of an Intelligent Technical Information System

Introduction: Current Problems

Professionals in nearly every area of education, business, and industry are challenged by a flood of raw information which can overwhelm human comprehension. Computerized data bases now exist which provide access to vast amounts of information, and the amount of information is growing and changing rapidly, approximately doubling every eight years. The introduction of optical disc (CD/ROM) storage technology as a microcomputer peripheral has expanded access to information and at the same time exacerbated the problems of information management and utilization.

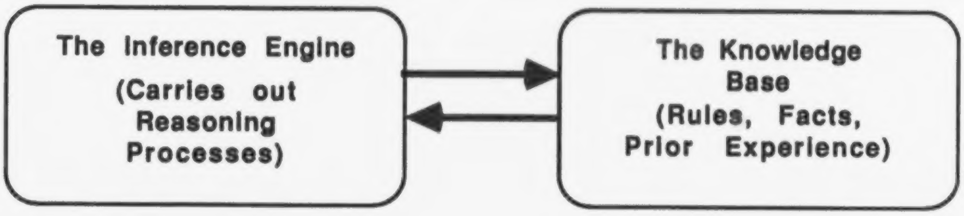
A Potential Solution to Information Overload: Intelligent Data Bases

A potential solution to the problem of information overload exists in the form of the development of "intelligent data bases." Intelligent data bases attempt to combine techniques used in artificial intelligence for knowledge representation and the development of knowledge-based systems with existing data base management techniques developed to store large amounts of data.

Intelligent data bases take advantage of the existing power and flexibility of traditional relational data base management systems (DBMS). Existing DBMS's have the advantage that they are already developed and highly refined, that they can store large amounts of information, and that the information is carefully structured and well organized.

Intelligent data bases apply the technology of expert systems to help researchers identify and focus attention on information relevant to a particular problem. An expert system is "a computing system capable of representing and reasoning about some knowledge-rich domain, such as internal medicine or geology, with a view to solving problems and giving advice" (Jackson, 1986, 1). Figure 1 illustrates the two major components of an expert system, the inference engine and the knowledge base, and the interrelationships between those components.

Figure 1
The Structure of an Expert System


The Inference Engine
(Carries out Reasoning Processes)
The Knowledge Base
(Rules, Facts, Prior Experience)

Both the specific information about the domain (that is, facts) and the process by which a human "expert" would solve problems in that domain, are represented symbolically in an expert system. Techniques used to represent knowledge include the use of production rules, structured objects, and predicate logic. For example, in an intelligent data base rules such as constraint checks or checks on the integrity of information referenced by the record can be associated with a data base record, resulting in a data base made up of active or intelligent objects.

A Case Study: A Knowledge Base for Steel Structures

Development of one such intelligent data base is currently in progress at the Technical Information Center for Steel Structures (TICSS) at Lehigh University (Harvey, Stewart, and Beedle, 1987). TICSS is part of the Center for Advanced Technology for Large Structural Systems (ATLSS), an Engineering Research Center at Lehigh funded by the National Science Foundation. The objective of TICSS is to identify the knowledge pertinent to all aspects of steel structures and to make it available for use. The knowledge base will include bibliographical material, technical data, and such other resources as research in progress, case studies, and the particulars about major projects. Professor Lynn S. Beedle, Civil Engineering Department, and the author are principal investigators for the project. TICSS faculty and students come from both the College of Education and the College of Engineering and Applied Science, and work jointly to develop and test applications of technology which will facilitate access by both students and practicing engineers to state-of-the-art information in a variety of forms.

Planning TICSS: Selecting Appropriate Hardware

Planning decisions during the first year of the TICSS project dealt with determining the scope of information to be collected, and identifying the suitable hardware and software environment. MS-DOS microcomputers were selected because most professional engineers used this system and TICSS was conceived as a distributed rather than centralized information system.

Software Selection: Turbo Prolog as the Programming Environment

Turbo Prolog (Borland, 1986) was selected as the programming language in which the initial information subsystems would be developed. Prolog (from PROgramming in LOGic) is a computer language based on a description of human reasoning in terms of formal logic. While most programming languages solve problems using procedures which prescribe how to solve the problem, Prolog uses statements describing objects and the logical relations between them (in the form of facts and rules) to describe what the problem is. The logical statements are interpreted by the computer as programs.

Turbo Prolog was selected as the programming environment to take advantage of its advertised built-in capabilities for creating and manipulating relational data bases. In addition, the information system could be extended by adding more facts and inferential rules to the Prolog program. Development of a knowledge-based system would therefore involve an evolution of the existing system, rather than starting over in a new environment, with the associated problems of converting data from one format to another. This decision has proved to have a major impact on the direction and rate of progress of the TICSS project.

Development of a Computer-Based Bibliographic Data Base

As a first step in developing an intelligent data base, a computer-manipulable information base of bibliographic information and other reference information on steel structures has been designed and is now nearing completion. Materials for the information base were obtained from existing hard copy and machine-readable information bases currently in the library of Lehigh's Fritz Engineering Laboratory, from other sources at Lehigh University, and from the American Institute for Steel Construction (AISC).

As noted above, the bibliographic system was designed in such a way that it could become part of a comprehensive knowledge-based system. The system also was designed for later conversion to optical-disc storage media (CD/ROM, CD-I, or other formats as they become available).

Description of the Bibliographic Data Base

The TICSS bibliographic data base was designed to accomodate information on fourteen different types of documents with a total of 35 fields. The system uses screen templates to guide data entry, and was designed to be very flexible. For example, the bibliographic data base was designed to accomodate documents with any number of authors or editors; it permitted the entry of any number of keywords; and abstracts and comments could be of any length. As noted previously, the original version of the bibliographic system was designed to utilize the built-in relational data base capabilities of Turbo Prolog; thus, the information was stored in sixteen separate files.

A prototype of the relational data base was developed and tested during the spring and summer of 1987, and the program is now being extensively revised based on the experiences with the prototype. The following section will discuss the positive and negative outcomes of experience with the prototype, and describe how plans for the development of future TICSS information systems were modified based on that experience.

Lessons Gained from Experience with the Prototype

Programming in logic rather than in procedures was a very different experience and proved challenging. Programmers had to get used to the different way in which problems had to be conceptualized in designing a Prolog program. Once this cognitive shift was accomplished, however, the programming expertise gained proved valuable in planning and designing the expert system to be developed as the next phase of the TICSS project.

Although Prolog is a very efficient environment for describing and programming facts and logical relationships, some programming tasks which are straightforward in other programming languages turned out to be cumbersome in Prolog. Programming data entry screens, for example, took much longer than anticipated. This situation was improved considerably when the Turbo Prolog Toolbox (Borland, 1987) became available in late Spring, 1987. The Toolbox consists of an extensive set of utilities to facilitate the development of procedures for user input, screen design and layout, menus, graphics, communication with remote devices, and conversion of data from other systems. Extensive use of the Turbo Toolbox procedures is being made in revising the bibliographic data base program.

Prolog is a list-oriented language, so project programmers were able to capitalize on their previous expertise with other list-oriented languages. Designing the data structure as lists and lists of lists, and developing programs to manipulate those lists, was therefore a relatively straightforward task.

A major disappointment was the speed with which the Turbo Prolog program was able to carry out data access and retrieval by means of its built-in relational data base procedures. Turbo Prolog is a compiled language, and executes programs as machine language. However, even with a small number of records (approximately twenty in the original prototype version), writing to files during data entry was very slow, and search and retrieval processes seemed to take forever.

It was clear that, with the approach taken with the prototype software, Turbo Prolog would not be able to meet project needs. Thorough review and analysis of the prototype program and the design specifications of the bibliographic data base were then undertaken. Options considered included changing completely to a commercial relational data base manager such as DBASE III, changing to a more powerful hardware environment which would support the use of more powerful versions of Prolog, and re-designing the program within the Turbo Prolog environment. The latter alternative was judged to best meet project needs, and a totally redesigned and rewritten version of the bibliographic data entry program is now nearing completion. The new version uses one large ASCII archival file instead of multiple relational files for data storage, and makes extensive use of index files and search algorithms developed by project programmers to provide fast and efficient Boolean searching of the archival file. Turbo Toolbox procedures for screen management are being extended to provide a friendlier user interface.

Impact on the Future Direction of the Project

As a result of the experience with the Turbo Prolog prototype, we are exploring the use of a variety of environments for development of additional information subsystems for TICSS. For example, a data base of computer software for engineering applications and a mechanism for identifying current research will be developed in DBASE III+ and procedures for converting DBASE III+ data into a form compatible with the Prolog information system will be developed. A change of both hardware and software environments is actively being considered since the experience of the project has demonstrated that the original environment is probably too limited to meet the needs of the Technical Information Center for Steel Structures.

Future Project Activities

Objectives for the second year of the project are to test the extensively revised bibliographic data base with a variety of users, and to expand the range and usefulness of the data base both by entering additional bibliographic information and by extending the range of types of information which will be included. Eventually the full knowledge base could include information on "documents" of the following types:

- bibliographies (reports, theses, journal articles, books, and design guides)
- technical data
- case studies (and digests)
- current research activities
- slides
- inventory of "large structures"
- project descriptions
- directory of professional specialists
- computer software
- films
- audio- and videotapes
- research results.

At the same time, the incorporation of all data bases into true knowledge-based systems will be explored. Approaches now being considered for combining traditional data base management system capabilities with the power of knowledge-based systems are illustrated in Figure 2 (see following page). These include:

- Adopting or developing a system in which the capabilities of the data base management system (DBMS) are included within a knowledge-based system (KBS);
- A system wherein the KBS accesses the DBMS after a search query has been formulated, that is, where the KBS acts as an "intelligent front end" to the DBMS;
- Utilizing an oversight management system which accesses both the KBS and the DBMS as appropriate and coordinates the exchange of information between the two systems.

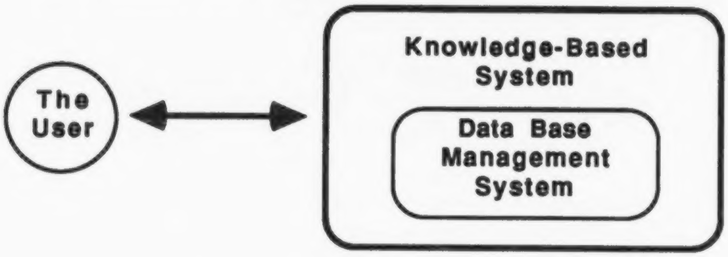
During the second year of the project a plan for converting the system to optical disc (CD/ROM) storage will be developed. In addition, a variety of research projects are now being planned to support these efforts.

Objectives for the third year are to continue to expand the scope and contents of the system and to complete the development of the system for steady-state operation, to complete conversion to optical disc format, and to implement a marketing plan.

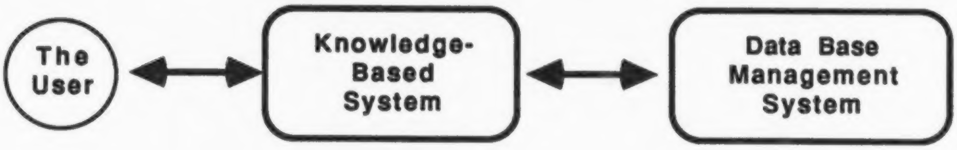
Figure 2

Design Approaches for Intelligent Data Base Systems

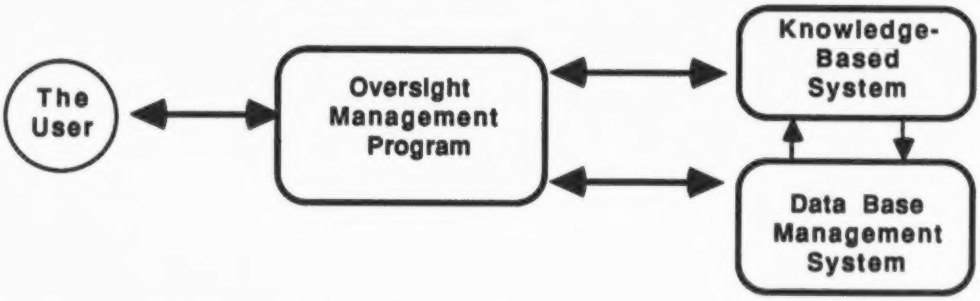
1. Include Data Base Management System (DBMS) Capabilities within Knowledge-Based System (KBS)


The User
Knowledge-Based System
Data Base Management System

2. Knowledge-Based System acts as "Intelligent Front End" to Data Base Management System


The User
Knowledge-Based System
Data Base Management System

3. Use of Oversight Management Program To Control and Coordinate Access to and Between Knowledge-Based System and Data Base Management System


The User
Oversight Management Program
Knowledge-Based System
Data Base Management System

Potential Research Questions Concerning "Intelligent" Information Systems

The advent of new systems of information access opens up a wide range of research questions related to the representation and utilization of knowledge. The following list of potential research questions is representative but by no means exhaustive.

- A comparison of the relative effectiveness of representing knowledge to the user in different ways, for example by the use of icons compared with menus, or graphically compared with tabular data;
- Identification of more effective ways to make use of the expertise of the professional expert who is intimately familiar with the information in the system and who knows

how to apply given criteria to select appropriate subsets of the information system. Translating the insights of such an expert to a set of instructions in a computer program is a major component of the development of a knowledge-based system.

- Investigation of how people develop and utilize higher-level search strategies. For example, strategies which utilize Boolean logic rules (intersection, union, negation) and combinations of Boolean rules (for example, metal fatigue AND welding techniques BUT NOT bridges) to select appropriate information from a large data base.
- Differences in cognitive style and information processing techniques utilized by people when working with computer-based (on-screen) information compared to traditional print materials.

Summary

This paper has described the ongoing development of a project through which information can be more thoroughly comprehended and more properly utilized through the application of artificial intelligence techniques. The project illustrates one way in which artificial intelligence can be applied effectively to problems of the real world.

Instructional developers and researchers in educational technology, as well as all educators, face the problems caused by an explosion of information related to their profession. The advent of new systems of information access opens up a wide range of research questions related to the representation and utilization of knowledge. The potential effectiveness of emerging information systems is enormous. Educational researchers can play a central role in helping these systems meet their potential by providing guidance in terms of thorough and valid research on issues related to the design and utilization of "intelligent" information systems. Artificial intelligence, therefore, offers new opportunities for educational research at the same time if offers potential support in identifying and utilizing professional information. We appear to be at the beginning of a new era, an "Age of Information." The implications of the changes that are rapidly taking place around us have not been fully recognized. The investigation of how professionals access and make use of the vastly increased amount of information available is a fruitful area of study.

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Title:

Operationalizing Cognitive Constructs in the Design of Computer-Based Instruction

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OPERATIONALIZING COGNITIVE CONSTRUCTS IN THE DESIGN OF COMPUTER-BASED INSTRUCTION

Gary A. Hettinger
January 15, 1988

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ABSTRACT

The application of theory to the design of computer-based instruction (CBI) has been problematic due to missing substantive linkages between that theory and CBI development. A match between student's cognitive characteristics and the learning transaction may enhance learner satisfaction, reduce time on task and maximize learning. One body of theory that promises a significant impact on CBI development is that of cognitive styles. Greater efficiencies in student learning may be obtained by matching the individual's cognitive style with instructional presentations designed to enhance that cognitive processing. An important question to address is how to design the courseware and which cognitive style theory to employ.

STATEMENT OF THE PROBLEM

The computer has been used for the delivery of educational courseware for the last twenty years, but comparisons between computer-based instruction and other forms of instruction have demonstrated essentially no difference in achievement between the delivery systems (Clark 1982). Why is there no difference given the potential for individualization within the learning transaction? Perhaps the answer lies in the design of the computer courseware itself and not in the technology. The problem to be investigated in this paper is; Can computer-based courseware be designed to address specific learner characteristics, and if so, on which learner characteristics should the designer focus and how can those characteristics be addressed in the courseware?

Foundations

Educators strive to develop instructional material and presentation methodologies that are more effective and efficient than those which have gone before. Two approaches that have resulted from these efforts are those of mastery learning and individualization of instruction. These two complementary approaches represent attempts to address the goals of optimization and transfer of learning. Operationalizing these approaches has been difficult due to the many uncontrollable variables and individual differences commonly found in the learning situation. We know, for example, that individualization can enhance learning but is difficult in large groups. One way to overcome this difficulty is to provide individual delivery programs tailored to each learner. In this way the instruction is delivered to each individual in a format that is more easily processed.

Another variable that is difficult to provide for in large groups is sufficient time on task. The time it takes any given learner to master information is both variable and individual. If we could provide for these and other variables across a range of individual differences, then perhaps learning time could be reduced and comprehension enhanced. Individual tutoring for all learners could provide for this level of interaction but is obviously impractical. The identification of salient individual differences and their application to instruction in a flexible format could provide this level of interaction for every learner.

One such flexible format, computer-based instruction (CBI) holds great promise for the optimization and transfer of learning. The computer has the dynamic potential to perform many pedagogical functions such as; present information, focus attention, engage the learner in discussion, lead the learner to the correct response, provide feedback, branch for remediation based on learner response, allow for individual differences, test for mastery, branch from pretest to information required, present moving graphics, show real time action, video etc.. Within each of these categories more potential is hidden, and the number of categories that could be addressed are limited only by the imagination.

Computer-Based Instruction

Computer-based instruction, unlike traditional instructional methodologies, offers greater control of many previously uncontrollable variables. For example, the computer offers control of the learning environment, almost limitless adaptation capabilities and a full range of audio and visual inputs and outputs. The learner characteristics remain the same in both traditional instruction and computer-based instruction, but the use of computers in education can allow greater control of both the learning environment and instructional presentation. Why then has the promise of CBI gone unfulfilled?

Kulik's meta-analysis (1980) found computer-based instruction to be a more effective learning tool than all other presentation methodologies. Clark (1982),however, refutes Kulik's findings. He explains that most of the differences in performance described by Kulik's analysis can be explained by relative differences in the amounts of planning and instructional design time devoted to the competing presentation methodologies in the studies analyzed. The findings that CBI by requires more time to design and develop comes as no surprise. And while we concede that the application of the systematic development of instruction has improved the quality of computer-based instruction, any presentation methodology may benefit from that same process. However, even when course materials are identical, the computer offers conditions and options to the learner that cannot be efficiently applied in any other presentation methodology.

The lack of difference in performance between traditional presentation methodologies and CBI described by Clark may be explained by the fact that critical learning theory is not being systematically applied to development of computer-based instruction This fact suggests that until such learning theory is more clearly articulated to the developers, CBI can only be an alternate presentation media; no better or worse than those compared to it. Therefore the potential optimization of learning through CBT will not be achieved. What factors are involved in the optimatization of instruction?

Optimizing Instruction

Optimal instruction is that set of learning activities which minimizes cognitive resistance to the material to be learned. In other words, optimal instruction for one learner is not optimal for different learners with different sets of learning characteristics, (i.e., different cognitive styles). Attempts to maximize learning have focused on learner adaption, mastery, knowledge structure, and individualization.

Learner Adaptation

Adapting the learner to the learning situation in order to maximize performance shows some promise (Snow, 1984). However, care must be taken in this attempt to teach learning strategies rather than changing the presentation , since the learner is not necessarily the best judge of instructional method. Clark, (1982) found,"evidence in ATI (aptitude by treatment interaction) studies that students tend to report enjoying the instructional method from which they learn least." Based upon this information we cannot depend on the student to make the choice of a presentation methodology that will maximize their learning and transfer. A better approach, perhaps, would be to modify the instructional presentation to match with the learners' dominant learning pattern. The application of research on cognitive style to the learning task via the computer offers great potential for the maximization of learning.

Snow (1984) found in his study of Aptitude by Treatment Interaction (ATI) that, "the treatment that is mathemagenic (i.e., gives birth to learning) for one kind of learner appears to be mathemathanic (i.e., gives death to learning) for another kind of learner, and vice versa." This principle makes it increasingly important that the mathemagenic approach be identified and pursued. Applications of expert systems to CBI make it increasingly possible to mold instructional presentations to learner characteristics. This study will attempt to relate some learner characteristics to specific learning principles, thereby laying the groundwork for more specific application of these principles.

Mastery Learning

Each individual is different from his fellow in many ways, and learning is not the least of these. Bloom (1968) proposes that when learners with normally distributed aptitudes are given uniform instruction in terms of quality and time, their achievements will also be normally distributed, and there will be a high correlation between aptitude and achievement. However, if learners with normally distributed aptitudes are given instruction that is optimal in terms of quality and required learning time, the majority of learners could be expected to achieve mastery, and there would be little or no correlation between aptitude and achievement.

Bloom assumes that time is the critical factor in maximizing learning. Time on task, however, is just one of many factors that contribute to learning. Bloom also refers to "optimal instruction" which he defines as individualized instruction. What set of characteristics or traits should the instruction reflect?

Structure of Knowledge

Gardner (1983) and Sternberg (1985) point out that learning is based upon two components: the learner and the material to be learned. Posner (1978) suggests that the structure of knowledge itself affects the "storage, retrieval, and utilization of knowledge" and that "previous experience and existing knowledge affect perception, communication, learning and performance of tasks." Reif and Heller (1982) suggest that in the teaching of physics, "considerable attention be paid to the organization of the knowledge acquired by students; that students be taught to structure their knowledge in hierarchical form; and that such knowledge be accompanied by explicit application guidelines." These recommendations were based upon research in the teaching of physics,but have implications for other quantitative sciences, as well.

To accomplish this effectively, a serious re-examination and synthesis of the principles of human cognition as they apply to the design of instruction for this medium is required. To accomplish this we must establish the existence of differences among various cognitive styles in the processing of information.

Individual Differences

The most important variable to be considered in the learning transaction is the learner. He brings a unique package of concepts, precepts and experience to the learning situation. This uniqueness has been referred to by many researchers as individual differences. Individual differences are many and varied. Those differences which facilitate or impair learning are critical but often ignored in the learning situation. Group instruction will often present the information in a manner thought to address the average learner. Intelligence according to Gardner is not as simple a concept as the number on an I.Q. test, he postulates different intelligences by conceptual areas. I.Q., of course, is but one individual difference. Cognitive style underlies the perception and interpretation of the learners environment. and perhaps contributes to intelligence. These interrelationships are unclear and require further research. We do know, however, that there exist a set of measurable cognitive controls and styles. One cognitive style that has been well established and researched will form the basis for this study.

Learning via traditional approaches suffers and sometimes benefits from continuity between classes, consistency of delivery, consistency of content, interaction between students, interaction between teacher and student, and class dynamics, to mention a few. Individualization of instruction has been introduced to address these problems, but class size and time available for instruction reduce its efficacy in the classroom. The typical approach to individualization has often been small group instruction and remediation.

Approaches that focus on the individualization concepts have been attempted in the print medium with varying success. Here the problems of student motivation and pacing impact with learning. An approach that is ideal for one student often fails with another. Attempts to remedy this problem have resulted in multi-media and multi-methodological approaches in which a student may be presented with as many instructional formats as it takes to achieve mastery. Transfer of learning in enhanced by this approach, but efficiency of learning is not.

Cognitive Style Constructs

Studies begun in the early nineteen hundreds applied these scientific principles to human behavior in order to identify differences in the way people respond to ranges of situational variables. Spearman (1927), Lewin, Lippitt, & White(1939) are examples of this movement. The outcome of these early studies began to show that individuals did in fact process or perceive there environments differentially. Early thought centered around the identification of traits, abilities and attitudes. In order to answer questions related to these traits, abilities and attitudes, they soon branched into studies of why there was a difference in processing environmental information to the identification of some of those differences. The construct of cognitive style was hypothesized to identify these differences in perception of environmental stimuli. Rather than explaining those differences in perception, the concept of cognitive style describes those differences. However, no adequate integration of the many cognitive styles, cognitive controls and individual differences has been accomplished to date. This fact does not degrade the concept that research into the separate cognitive styles can build upon the past research in a particular cognitive style. There is however some commonality between certain of the concepts.

That individuals have a collection of innate traits and abilities that mediate interpretation of stimuli is well established. They also learn strategies, programs or transformation operations to translate objective stimuli into meaningful dimensions (Bieri, 1971). Cognitive styles are therefore defined in terms of "consistent patterns of organizing and processing information that mediate between environmental input and the organism's output" (Messick, 1976) and "organize behavior as well as input " (Zajonc, 1968).

Field Dependence/Independence Dimension

Messick (1970) has summarized work in cognitive styles into nine categories. Many conceptual differences between and among the categories exist. No attempt as yet has integrated the cognitive styles into an information processing model, so we are left with the separate concepts of cognitive styles that may be applied in learning presentations.

Thompson (1979) found that the cognitive style of field dependence/ field independence was directly related to learning achievement. It is also this concept that has been most extensively studied. This dimension of cognitive style, offers considerable evidence concerning the processing of information which is applicable to the computer-based instruction environment. The field dependence/independence concept is described by Witkin as being bipolar. "At one extreme of the performance range perception is strongly dominated by the prevailing field (field dependence)" and "at the other extreme, where the person experiences items as more or less separate from the surrounding field, the designation 'field independent' was used." (Witkin, Moore, & Goodenough, 1977). The dimension described by Witkin was first identified in the investigation of perception, and it was further defined as having educational application. "Extensive evidence, accumulated over the years, shows that the styles we first identified in perception manifest themselves with symbolic representations, as in thinking and problem solving." (Witkin, 1977,). When Witkin found that the perceptual tasks he identified as field dependent/independent were related to non-perceptual intellectual tasks, the underlying construct was broadened to a "global-articulated" dimension. The field-independent person prefers to approach the environment in analytical terms as opposed to a preference for experiencing events globally in an undifferentiated fashion. Witkin (1977) relates that:

> "Studies of the role of cognitive style in student learning have used both the cognitive and social characteristics constituent in the articulated-global dimension to conceptualize relations between learning behavior and cognitive style. Of the four learning areas we consider, the first two have used the social characteristics as a bridge between the domains. These two areas are learning of social material and the effects of social reinforcement. The third and fourth learning areas used mainly cognitive characteristics as a bridge. These are the areas of mediating mechanisms in learning and cue salience."

Field Independence

The field independent person experiences in an articulated fashion and tends to perceive items as discrete from their background when the field is organized, and to impose structure on the field, and so to perceive it as organized He/she is generally facile on tasks requiring differentiation and analysis, whether in identifying the presence of logical errors or in understanding the point of a joke. This analytical penchant leads to a high degree of differentiation of the self from its context (Anderson, Ball, Murphy, 1975). Witkin (1977) found that, "field independent persons are more likely to use mediators, of their own design, in dealing with a learning task.

Field Dependence

Field dependent persons are more likely to rely on characteristics of the learning task itself "rather than create mediators and that has a tendency to favor a spectator over an hypothesis testing approach" (Witkin, et.al; 1977) In contrast, it may be said that, "experience is more global when it accords with the overall character of the prevailing field as given, and involves less intervention of mediators such as analysis and structuring". (Witkin, 1977).

In summary, Witkin found that performance on perceptual tasks was related to performance on non-perceptual tasks. He broadened the concept to an "articulated global", the dimension on which people tend to structure their perceptual field. The components that delineate the concept of the "articulated global" dimension are the need for social reinforcement, the learning of social material, importance of cue salience, and mediation in problem solving,

It is proposed that a marriage between CBI design components and cognitive structures of the individual utilizing the material would maximize information transmittal and minimize the time element required for learning, thereby making instruction more efficient and effective. The question remaining, however, is that of how to operationalize those cognitive constructs in the FD/FI cognitive style.

Operationalizing Cognitive Components

In order to utilize the components of a particular cognitive style in the design of instruction, the significant components must be identified. Once identified, corresponding treatments must be devised.

Many FD/FI characteristics have been identified in the literature, but, only those characteristics identified by Witkin (1977) and Renninger (1983) as having educational implications were considered in the development of the lesson to be used in this study. Instructional strategies were then applied to these cognitive style learner characteristics. For example, the Field Dependent learner, according to Witkin (et. al. 1977), has the following characteristics/requirements;

- an interpersonal orientation,
- extrinsic motivation,
- reinforcement,
- social cues,
- help sequences,
- structure,
- goals,
- feedback, and
- salient relevant cues.

The concept of FD/FI is bi-polar, therefore, the opposite characteristics apply to the Field Independent learner. Instructional strategies were then matched with these learning characteristics to create the treatment lesson. The two treatments or branches are characterized by the inclusion or exclusion of these instructional strategies while keeping the content constant.

In order to guide the development of the two treatments a design matrix was developed. The following matrix groups the cognitive characteristics into categories according to their similarities and identifies those strategies believed by the author to address those cognitive characteristics. The lesson material for each branch was then constructed to reflect these instructional strategies.

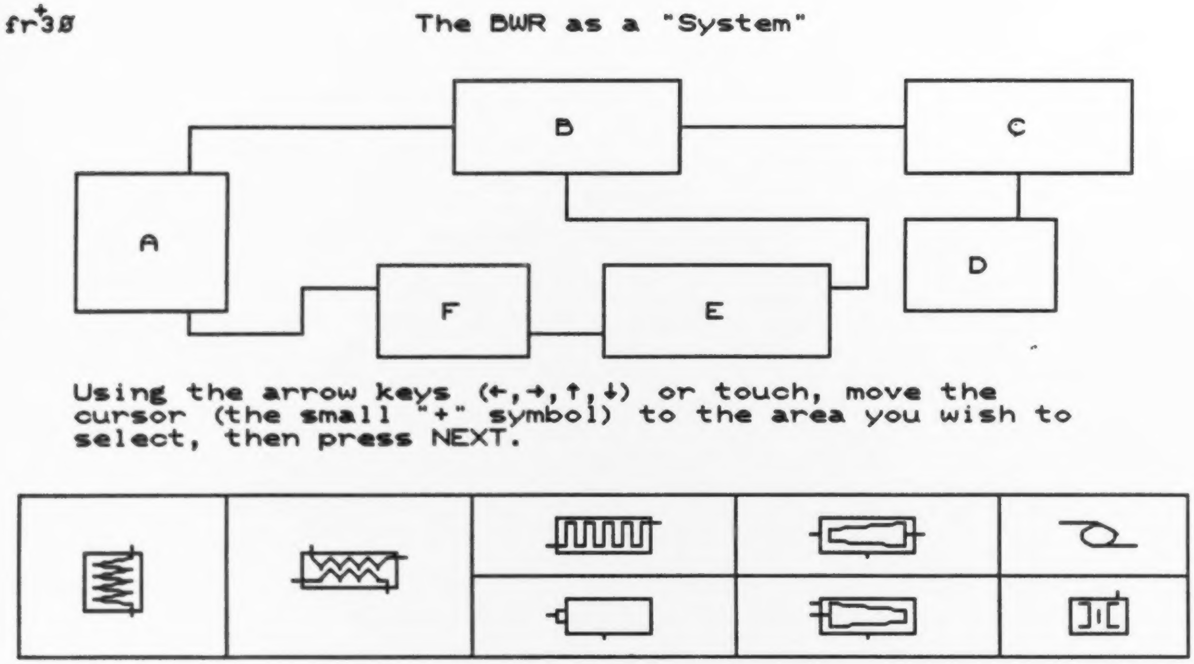
(Figure 1)

COGNITIVE STYLE LEARNING
CHARACTERISTIC/INSTRUCTIONAL STRATEGY MATRIX

FIELD DEPENDENT			FIELD INDEPENDENT	
INSTRUCTIONAL STRATEGIES	LEARNER CHARACTERISTICS Spectator Approach		LEARNER CHARACTERISTICS Hypothesis Testing Approach	INSTRUCTIONAL STRATEGIES
PERSONALIZED FEEDBACK	INTERPERSONAL ORIENTATION	↔	SELF RELIANT	NO PERSONALIZED FEEDBACK
	EXTRINSICALLY MOTIVATED	↔	INTRINSICALLY MOTIVATED	
	REINFORCEMENT NECESSARY	↔	REINFORCEMENT UNNECESSARY	
	SOCIAL CUES NECESSARY	↔	SOCIAL CUES UNNECESSARY	
PROVIDE ONLINE HELP	HELP SEQUENCES UTILIZED	↔	INDEPENDENT PROBLEM SOLVING APPROACH	HELP OPTION ONLY IN BEGINNING
LEARNING STRUCTURE PROVIDED	FUNCTIONS WITHIN CONCEPTUAL STRUCTURE PROVIDED	↔	STRUCTURES CONCEPTUAL ENVIRONMENT FOR COGNITIVE PROCESSING	DISCOVERY APPROACH NO STRUCTURE PROVIDED
	RELIES ON CHARACTERISTICS OF LEARNING TASK ITSELF	↔	CREATES OWN MEDIATORS FOR LEARNING TASK	
	CONTEXT ORIENTATION	↔	CONTENT ORIENTATION	
OBJECTIVES STATED	GOALS NECESSARY	↔	REDEFINES PROBLEM GOALS IN OWN TERMS	ONLY BROAD GOAL PROVIDED
ERROR RELATED FEEDBACK	FEEDBACK NECESSARY	↔	FEEDBACK UNNECESSARY	RIGHT/ WRONG FEEDBACK FIRST TWO TRIALS
TASK RELATED FEEDBACK	RELEVANT CUES MUST BE SALIENT	↔	RELEVANT CUES NEED NOT BE SALIENT	THIRD FEEDBACK WILL CONTAIN CORRECTIVE FEEDBACK

Example

The design of any courseware is a creative endeavor.and design approaches differ dramatically. To illustrate one approach in an attempt to operationalize the cognitive constructs of field dependence and field independence, the author has chosen a lesson in Thermodynamics Two branches were created, one for each of the cognitive styles represented in the design matrix. The field dependent branch most closely resembles what can be considered the traditional, spectator approach to CBI design. Objectives are stated early in the lesson, content presented in graphic and text and finally questions presented.with personalized, error related feedback. Help is always available. The field independent path represents an hypothesis testing approach to CBI design. Features in this path include broad goals instead of specific objectives, right/wrong feedback without further cues, and a discovery approach to interacting with the materials. Help is available only at the beginning of this branch.



fr30

The BWR as a "System"

Using the arrow keys (←,→,↑,↓) or touch, move the cursor (the small "+" symbol) to the area you wish to select, then press NEXT.

Field Dependent Branch

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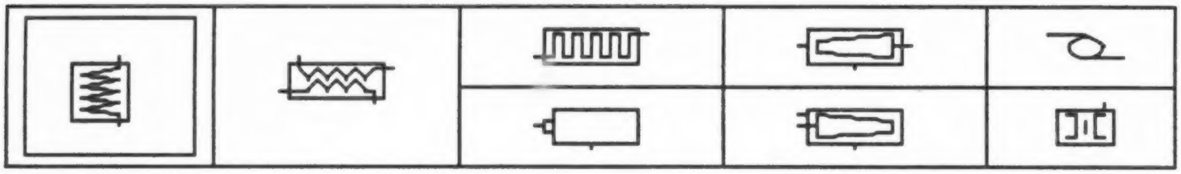
Use touch or the arrow keys (←,→,↑,↓) to select a symbol, then press NEXT. Press SHIFT-NEXT to judge your drawing.



Press HELP for a description of what each symbol represents.

Field Independent Branch

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Title:

The Effects of Selected CAI Design Strategies on Achievement, and an Exploration of Other Related Factors

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The Effects of Selected CAI Design Strategies on Achievement, and an Exploration of Other Related Factors

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The Effects of Selected CAI Design Strategies on Achievement: and an Exploration of Other Related Factors

Researchers have demonstrated that programmed instruction methods, using both computer and print technologies, can increase learning in many content areas and populations (Hannafin, 1985). It is apparent that good computer programs help learners learn. However, researchers must isolate variables systematically, and examine their effectiveness, in order to improve the design of computer-assisted instruction. The CAI design strategies under investigation in this study were type of control (internal vs. external) and feedback (immediate vs. delayed vs. no feedback). In internally controlled CAI programs, the option to select a branch is decided by the person using the program. In externally controlled programs, branches are selected for the learner, based on responses to embedded questions.

In addition, educators have speculated that personality characteristics can either interfere with or enhance learning by computers (Eisele, 1984). For example, Maurer and Simonson (1984) contended that computer anxiety can interfere with computer-based learning. Thus, the purpose of this study is not only to determine the effects of type of control and feedback on learning acquisition, but also to explore the influence of such factors as computer anxiety, self-concept, learning style, and gender on achievement, as well as to study how these factors correlate with each other.

Hazen (1985) declared that both learner control over CAI choices and non-threatening, positive feedback can keep learners motivated when working through CAI programs. The question is do these strategies aid learning?

Control Strategies

One of the more interesting issues in the area of computer-assisted instruction is the control of the instruction and where it should be placed. Internal-control strategies put the learner in charge of the instruction. External control allows some interaction between the instructional program and the learner, but ultimately the program determines the "path" through the instruction.

Research has been conducted which compares the effectiveness of internal-control strategies to external-control strategies. Sasscer and Moore (1984) asserted that "the research literature related to learner control of instruction is characterized by reports of contradictory findings and equivocal terminology" (p. 28).

Since learner control usually means that the individual is allowed to select options for additional or enhanced instruction, the research by Tobias (1984) has important implications. Treatments in Tobias' study offered students a choice of internal or external control. Findings suggested that even if students' selection of options was "frequently not wise or informed the mere selection of a control strategy increased cognitive processing and thus achievement was increased" (p. 8). When learner control and external control were more directly compared by Laurillard (1984), the conclusion was that students elect to branch when given that option and in such a variety of ways that "program control must seriously constrain the individual preferences of students" (p. 14). Additional research by Stevens (1984) suggested that greater amounts of learner control increased learning.

In contrast to research findings which favor the use of internal-control strategies, there is evidence that external control may better serve learners' needs. Belland, Taylor, Canelos, Dwyer and Baker (1985) found that external pacing resulted in somewhat higher achievement than internal pacing. These findings were confirmed in studies by Dwyer, Taylor, Canelos, Belland and Baker (1985) and Canelos, Baker, Taylor, Belland and Dwyer (1985). These findings support much earlier research by McLaughlin and Malaby (1974). When students were permitted to work through units at their own pace, they completed fewer units than did students who were directed to complete a specific number of units per day.

Some support also has surfaced for an approach which advises the student about branching decisions. However, this is almost a form of external control, since the computer program does influence decisions. Research by Tennyson and Buttrey (1980) and Tennyson, Tennyson and Rothen (1980) found this adaptive or advisement strategy to be superior to both external and internal control in computerized instruction.

Research also exists that shows conflicting results for type of control strategy. As early as 1979, Mabee, Neimann and Lipton discovered no significant differences between self-paced (internal control) and instructor-paced (external control) learning. More recently, Goetzfried and Hannafin (1985a, 1985b) found no significant differences between groups utilizing internal-control, external-control and linear (no control) CAI programs. This supported the earlier non-significant findings of Dunn (1971), who examined review strategies which were either internally or externally controlled. One reason for the lack of significant differences in these studies was suggested by Garhart and Hannafin (1986), who concluded "that learners are not good judges of their en route comprehension" (p. 12).

Feedback

For most of this century, it has been stated that frequently administered feedback aids learning (Pressey, 1926; Skinner, 1954). However, many researchers have found that knowledge of results and reviews have not had a significant effect on learning acquisition (Cohen, 1985; Dunn, 1971; Gilman, 1969), although other studies have found certain feedback strategies to be effective (Kulhavy, 1977; Tennyson & Buttrey, 1980). For example, Gilman (1969) reported that varying how content was presented worked better than did repetition to improve learning, after incorrect responses were made.

Sassenrath (1975) reported that delayed feedback was superior to immediate feedback generally, although Joseph and Maguire (1982) expressed doubt about the effectiveness of delayed over immediate feedback, after studying this variable in a variety of learning situations. Furthermore, when Hodes (1984-1985) compared the effects on learning of corrective feedback (i.e., encouraging students to make further attempts to give the right answer) and noncorrective feedback (i.e., not encouraging and even discouraging students to make the correct response), no statistically significant differences were found.

Individual Difference Variables

Computerphobia has been defined as the resistence to the subject of computers and avoidance of them, as well as fear, anxiety or hostility towards computers (Jay, 1981; Maurer & Simonson, 1984). This condition generally manifests itself in the form of negative statements about computers and their use (Maurer & Simonson, 1984). Researchers have demonstrated that people who have had some experience using computers have more positive attitudes towards them than do inexperienced people (Kulik, Bangert & Williams, 1983; Loyd & Gressard, 1984; Tyagi, 1984). Jonassen (1986), however, found that no relationship existed between level of computer experience and state anxiety when using a computer.

According to Mercant and Sullivan (1983) and Winkle and Matthews (1982), females had less favorable attitudes towards computers than did males, as well as higher levels of computer anxiety. Although both negative attitudes and high anxiety can have deleterious effects on learning, neither of these relationships has been investigated thoroughly. Furthermore, it has not been demonstrated conclusively that males have significantly better attitudes towards computers than do females. In fact, Loyd and Gressard (1984) and Swadener and Hannafin (1987) found no significant differences statistically when investigating gender differences and attitudes towards computers.

There is some evidence to suggest that a positive correlation between high self-concept and academic achievement, in general, exists (Green, 1977). However, the relationship between self-concept and learning from CAI programs has not been thoroughly explored. Although both low- and high-achieving learners can benefit from CAI, it has not been shown that self-esteem can be improved significantly by CAI (Dalton & Hannafin, 1984), or even that those with good self-concepts learn better from CAI programs.

Recent interest in researching individual differences is an encouraging sign for education. Hoffman and Waters (1982) stated that CAI is best for individuals "who have the ability to quietly concentrate, are able to pay attention to details, have an affinity for memorizing facts, and can stay with a single task until completion" (p. 51). Smith (1985) found that visually perceptive students achieved better in a CAI presented learning task than did the nonvisually perceptive. Hedberg and McNamara (1985) found "that the interaction of feedback with cognitive style did not improve the performance of field independent subjects" (p. 14). In fact, field independent subjects were negatively influenced by feedback. Hannafin (1985) suggested that learners whose locus of control was internal made more accurate and effective instructional-control decisions than learners whose locus of control was external.

Learning style has been defined in a number of ways, which include the learner's preferences for a number of instructional techniques (Ristow & Edeburn, 1983). However, as pointed out by Enochs (1985), learning style generally is concerned with an individual's preferences for learning abstractions or more concrete information. They found that concrete learners learned more from CAI than did more abstract learners. Kolb and Baker (1984) separated learning styles into two continuums: (1) the Active Experimentation, Reflective Observation continuum, and (2) the Concrete Experience, Abstract Conceptualization continuum. It is perhaps these learning styles which may prove to increase our knowledge of how individual differences interact with instructional techniques.

Methodology

Three hundred thirty-six undergraduate students from speech, communications and psychology were assigned randomly to one of seven groups. There were more females (60%) than males (40%) included in this sample, and the majority (60%) had never taken a computer course. Each of the CAI treatments was designed to include one or more of the independent variables under investigation.

The content of the CAI programs used in this study taught objectives for a college-level course in research. The content dealt with definitions and concepts in social-science research, including defining, stating the purposes of and discriminating among descriptive, experimental and historical research; dependent and independent variables; surveys and questionnaires; and types of sources.

The seven treatments can be described as follows:

1. Linear program. There were no embedded questions and therefore no feedback. No options were offered to the subjects and therefore no interaction took place. Students read each screen, pressed the return key and read the next screen until they were finished.

2. External control with no feedback. Subjects were asked questions about the content at certain points in the instruction. If they answered the question incorrectly, they were recycled through the instruction and asked the question again. This group saw all the screens that would eventually become options for the internal-control group.

3. External control with immediate feedback. Conditions were the same as for treatment #2, with immediate feedback given for responses to questions. Feedback screens appeared immediately after subject's responses.

4. External control with delayed feedback. Conditions were the same as for treatment #2, with delayed feedback given for responses to embedded questions. Once the subjects completed the CAI program, they were given feedback regarding the number of correct responses they had made before taking the post test.

5. Internal control with no feedback. Subjects were asked questions at certain points in the instruction before they were offered the opportunity to see additional instruction or to review what they

had just seen. Upon answering a question, they had the chance to continue or to go back and see the instruction again if they answered the previous question incorrectly.

6. Internal control with immediate feedback. Conditions were the same as for treatment #5, with immediate feedback included.

7. Internal control with delayed feedback. Conditions were the same as for treatment #5, with delayed feedback given.

The seven treatments were assigned randomly to the seven groups.

Data collection was conducted in two sessions. The first session introduced subjects to the purpose of the research and a number of tests and questionnaires, which represented a number of additional variables, were administered.

The first of these variables was computerphobia, measured via a Likert-type attitude scale developed by Maurer and Simonson (1984). The second variable was self-concept, as measured by the Tennessee Self-Concept Scale (Fitts, 1964). An overall self-esteem score was determined (i.e., Total P Score). The third variable was learning style, which was measured by the McBer and Company Learning Style Inventory, developed by Kolb and Baker (1984). Finally, a short demographic questionnaire was administered. All data on additional variables were collected in sessions attended by 30 to 70 subjects.

The second data-collection session was scheduled to take place in a microcomputer laboratory with each subject, who had to work individually. The subject was given the CAI program assigned to his/her group, worked through the program, and then took a post-test. This dependent measure was a 15-item, multiple-choice test, which was designed to measure learning from the CAI programs. The number of branches that each subject elected to take was recorded by the computer.

A 2x3 completely randomized factorial design, with fixed effects, with a control group was used in this study. The independent variable, Control, had two levels: (1) active, voluntary, internal control, and (2) passive, forced, external control. The other independent variable, Feedback, had three levels: (1) immediate, (2) delayed, and (3) no feedback. The control group received a linear program, with no feedback given. Data were analyzed using ANOVA techniques for main effects and interactions, as well as Tukey-HSD and correlational procedures.

Results

Both the within-cell and treatment-level means for the achievement measure, as well as the number of subjects under each condition, are shown in Table 1. The analysis of variance results are displayed in Table 2. No significant differences between means were found for either the control or feedback independent variable. It should be noted that the linear, no-feedback control group was excluded from these analyses. However, when Tukey's HSD test was employed to make all pairwise comparisons among the levels of the independent variables, the mean of the control group was included. Although the control group scored most poorly, Tukey's HSD procedure indicated that no two groups were significantly different at the .05 level.

An investigation of the relationship among various personality and demographic variables, number of branches taken by internal-control subjects, and achievement scores revealed a number of interesting findings. The results of the correlational analyses appear in Table 3.

Female students were found to be significantly more computerphobic than were males ($\underline{r}$ = .10) and not to have taken a computer course ($\underline{r}$ = .21). However, neither higher computerphobia nor lack of computer coursework were correlated with achievement scores. Furthermore, female students achieved significantly higher scores than did the males in the study ($\underline{r}$ = .10). It also was determined that students who had taken a computer course had more positive self-concepts than those who had not ($\underline{r}$ = .14).

In addition, females were found to have a more concrete learning style ($\underline{r}$ = .13), but were less reflective in their style of learning ($\underline{r}$ = -.10), than males. It was discovered that concrete learners were more computerphobic ($\underline{r}$ = .13). Furthermore, internal-control subjects who chose to select branches to work through had higher achievement scores than did students who did not branch as frequently ($\underline{r}$ = .33).

Discussion

Findings of no significant difference necessitate caution in drawing conclusions. No differences were uncovered for the main independent variables, Control or Feedback. With the simple, verbal-information learning task employed in this study, subjects seemed to be able to learn regardless of control strategy or method of feedback. The lack of significant findings for the independent variables can be attributed to two possible reasons. First, the great care taken to design seven effective CAI programs may have resulted in the development of instructional programs that failed to maximize experimental differences. Second, the simplicity of the learning task for these subjects may have led to a failure to show differences among treatment levels. However, findings of no significant difference are common in CAI research, such as in the study by Dalton and Hannafin (1984).

A number of additional conclusions were drawn based on data analysis. Subjects who chose to branch received information that allowed them to score higher on the achievement test than those who elected not to branch as frequently. Although females scored higher on the computerphobia scale, this did not interfere with their performance on an achievement test, after they worked through a CAI program. Could it be that the traditional differences between genders on such subjects as mathematics and computers is no longer a major factor? More concrete learners had higher computerphobia scores. Is the activity of sitting at a computer keyboard likely to raise anxiety among such learners? There may be a need for more research in such areas as the relationship of various learning styles to learning from CAI and other electronic learning aids.

More research needs to be conducted on how different types of individuals learn from microcomputer, and about how to make computer software more effective enhancers of learning. Microcomputers are rapidly becoming one of the most important media of instruction in our schools and in business and industry. Educators and trainers must be able to determine the best ways to use microcomputers. Learning achievement and efficiency can be increased possibly by the right combination of control and feedback strategies. With this in mind, a number of recommendations are offered.

1. This study should be replicated with different levels of learning tasks.

2. Different populations should be used in a replication of this study.

3. An examination of other possible correlational variables, or variables which represent other areas of individuals differences (such as locus of control and cognitive style), should be conducted.

4. A meta analysis of CAI research should be conducted to bring together all findings to date and lead to more recommendations for designing better programs.

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Table 1

Achievement Means and Subject Frequencies for Control and Feedback Factors in CAI Programs

Control	Feedback			
	Immediate	Delayed	No	
Internal	13.19 (16)	12.56 (18)	13.15 (13)	12.94 (47)
External	12.40 (40)	12.83 (47)	12.76 (45)	12.67 (132)
	12.63 (56)	12.75 (65)	12.84 (58)	

Note: The number of subjects in each experimental unit is in parentheses.

All internal-control subjects who branched fewer than 15 times were excluded from this analysis.

The Linear, No-Feedback Group had a mean of 12.26 and had 42 subjects.

Table 2

Analysis of Variance on Achievement Scores for Control and Feedback in CAI Programs

Source of Variation	*df*	*MS*	*F*
Control	1	2.59	.93
Feedback	2	.80	.29
Control x Feedback	2	3.54	1.27
Residual	173	2.78	

Table 3

Correlations Among Personality and Demographic Factors, Branching, and Achievement Scores

Factor	Achievement	Computer Course	Computer-phobia	Gender
Gender	.10*	.21***	.21***	
Computerphobia	.03	.16**		
Self-Concept	.04	.14**	-.06	.08
Learning Style (Concrete Experience)	.09	-.04	.13**	.13*
Learning Style (Reflective Observation)	-.07	.07	-.04	-.10*
Learning Style (Abstract Conceptualization)	.03	.00	-.05	-.08
Learning Style (Active Experimentation)	-.02	.00	-.05	.02
Branching	.33***	.09	.04	.07
Computer Course	-.09			

*p<.05   **p<.01   ***p<.001

Note: Number of cases ranged from 276 to 329 for all correlations, except for those involving branching (with data from 115 to 125 subjects analyzed).

Title:

Cooperative Learning at the Computer: Ability Based Strategies for Implementation

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Cooperative Learning at the Computer: Ability Based Strategies for Implementation

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Abstract

This study compares the achievement of high and low ability eighth grade students working cooperatively during computer-based instruction. Students were grouped either homogeneously or heterogeneously on ability, and received identical instruction on a fictitious rule-based arithmetic number system. No significant differences in achievement were found between the two grouping methods. However, the mixed ability treatment substantially improved the achievement of the low ability students without an accompanying significant reduction in the achievement of the high ability students. The results indicate that designers and teachers may have little to risk in terms of achievement, but potentially much to gain in socialization and interaction, by cooperative heterogeneous grouping during computer based instruction.

Cooperative Learning at the Computer: Ability Based Strategies for Implementation

Educators interested in the implementation of computers in education are concerned with identifying models that maximize learning. One model that has gained much recent attention involves the use of cooperative learning (e.g. Carrier & Sales, 1987; Johnson & Johnson, 1986; Johnson, Johnson, & Stanne, 1985; Mevarech, Stern, & Levita, 1987; Webb, Ender, & Lewis, 1986).

To many, cooperative learning has both strong intuitive appeal and compelling practical significance. The limited availability of computers in the classroom often mandates the use of group models (Hannafin, Dalton, & Hooper, 1987). Further, studies have generally indicated that students often work better in small groups than individually (Peterson & Janicki, 1979; Peterson, Janicki, & Swing, 1981; Swing & Peterson, 1982; Slavin, 1983). Consequently, assigning a computer to each student may be both unnecessary and unwise (Dalton & Hannafin, 1987).

Cooperative learning involves the selection of a number of students (usually between three and five) to work together in groups. Once selected, the degree of cooperation within groups can be manipulated by methods that control rewards. Group members can, for example, work toward cooperative, competitive, or individual incentives (Slavin, 1983). With a cooperative incentive all group members are rewarded identically, although the method of assessing group achievement may vary. Group members may receive either the score of the lowest achiever in the group, the average score of all the group members, or some other similar group reward. Competitive incentives involve comparison of all team members' scores, and rewards commensurate with success. Thus students may work together in the knowledge that helping other group members may actually reduce their own personal chances of success. Individual incentives may be offered to individual group members regardless of others' achievements.

Of particular interest are the relationships between student interaction and achievement and the effects of different grouping methods on resulting interaction. As part of an investigation into the influence of cooperative learning on achievement, Webb (1982) examined the effects of giving and receiving help during small group learning. She found that students who were active in the learning process, and who gave explanations to other students, showed higher levels of achievement than those students who were not actively involved in group interaction. Giving explanations involves forming associations between new and existing information, and also requires the learner to form elaborations (Webb, 1985). Elaborations, in turn, aid retrieval by forming alternative pathways for the construction of answers (Gagne, 1985). Webb also found that students who sought and then received help showed significant improvements in learning. Receiving help may engender an atmosphere of caring within the group which may in turn result in greater personal effort (Slavin, 1978).

How should cooperative groups be formed? How should learners of varying abilities be grouped to maximize the benefits of cooperative grouping? A description of the learning phases, proposed by Rummelhart and Norman (1978), may help to predict effective models of cooperative learning. They characterized learning as a process during which the learner passes through three stages of understanding. In the first stage, accretion, the learner is able to discriminate between examples and non-examples but is unable to apply knowledge to new situations, or to provide in-depth explanations. During the second stage, restructuring, the learner is still unable to provide deep explanations but can now transfer some learning. Finally the learner enters the highest level of learning, tuning, and is at last able to solve novel problems, to work effectively under stress, and to provide deep explanations.

This model suggests that low ability students working together in small groups are likely to flounder in an environment that requires group members to explain cognitively complex information: They are unlikely to reach the tuning stage for difficult tasks. Consequently, they would be unable to provide adequate explanations of the learning process to fellow group members. However, the model also suggests that students in both mixed and high ability groups may benefit from cooperative learning. High ability students may better organize information within their own cognitive structures by giving in-depth explanations (Bargh & Schul, 1980). This improved organization is likely to deepen understanding (Mayer,1984). Further, low ability students, grouped with high ability team members, are likely to receive more individualized and in-depth explanations than possible from the classroom teacher. The extra instruction is likely to increase learning for low students without corresponding decrements for high students.

One aspect of cooperative learning that has received little attention concerns the influence of grouping on the learning of increasingly complex tasks. While low level information generally does not require meaningful encoding, higher order skills, such as rule application and problem solving, often require deeper cognitive processing. While more able learners may impart strategies to less able students to learn simple information, it is unlikely that higher level learning will be achieved through a limited exposure to cooperative learning: Low students may simply lack the cognitive structures required for complex learning. Consequently, as the complexity of the learning task increases, the positive effects of heterogeneous ability grouping for low students will likely dissipate.

The purpose of this study was to extend research into computer-based cooperative learning by examining the effects of two methods of ability grouping, homogeneous and heterogeneous, on the learning of increasingly complex concepts.

Methods

Subjects

The subjects were 40 eighth grade students selected from a junior high school in a rural area. The students comprised approximately equal numbers of mainstreamed males and females from both the top and bottom ability levels of pre-algebra and general math.

Materials

Participants, working in small groups of three or four students, received a computer driven tutorial. To avoid the confounding effects of prior knowledge, the content was designed to be as content and culture free as possible. The content was based on basic arithmetic concepts that all students of this grade level should have mastered.

The tutorial comprised four sections. In the first section students were shown four different sets of novel symbols, corresponding to the arithmetic operations of addition, division, multiplication, and doubling and adding, as shown in Figure 1. Each set included three identical constants (1, 2, and 4), resulting in the following operations; divide by 1, divide by 2, and divide by 4; double and add 1, double and add 2, double and add 4. Multiple choice questions, as shown in Figure 2a, were then presented concerning the meaning of the symbols. After 10 successive correct questions students began the second section.

Insert Figures 1 and 2 about here

In the second section, four examples were presented that involved evaluating the combined values of two symbols. For example, add 2 followed by double and add 4 (answer 8). Students were then required to correctly evaluate five successive pairs of symbols, such as shown in Figure 2b, before beginning the third section.

In the third section, (see Figure 2c), students were required to evaluate strings of three symbols. Three successive correct answers were required to complete this section.

In the final section, students were given strings of five symbols to evaluate. Examples of these strings are shown in Figure 2d. Four successive correct answers were required to complete this section. Students could check the symbol meanings at any time by selecting a help screen that displayed all 12 symbols with their corresponding values. In all four sections, immediate feedback was given concerning the correctness of each response. Further, in the second, third, and fourth sections incorrect responses were followed by display of the correct answer.

To promote cooperation between group members, the tutorial contained an embedded strategy that required students to alternate roles after approximately every five questions. Each student received a card numbered 1, 2, 3, or 4. Each card specified the role to be played by the card-holder; decision-maker, advisor, or typist/advisor. Roles rotated when cards were exchanged among group members.

Treatments

There were three cooperative groupings: homogeneous high, homogeneous low, and heterogeneous. High ability subjects were defined as those from the pre-algebra math class, and low ability subjects were defined as those from general math. In the homogeneous high group, four high ability subjects were assigned to each of three groups; in the homogeneous low group, four low ability subjects were assigned to each of three groups; in the heterogeneous group, two high and two low ability subjects were assigned to each of six groups.

Posttest

To avoid the influence of recency, students received a delayed posttest: This was administered one week after the initial treatment. The posttest included 16 questions at three different levels: factual recall, application, and problem solving. Sample posttest items are shown in Figure 3.

Insert Figure 3 about here

Factual recall There were four questions which required recall of the meanings of the symbols. Three points were awarded for the correct operation and two points for the corresponding constant. The K-R 20 subscale reliability was .70 .

Application There were six questions which required calculation of strings of two, three, and five symbols. Five points were awarded for the correct answer but no partial credit was awarded. The K-R 20 subscale reliability was .76 .

Problem solving There were six questions at this level. To test problem solving, subjects were asked to generate strings of two, three, and five symbols that together formed a given number. Five points were awarded for each correct answer. Two partial credit points were awarded if the given answer was equivalent to the question, but contained no more than one too many, or too few, symbols. The K-R 20 subscale reliability was .84 .

The overall K-R 20 posttest reliability was .90 and the individual item difficulty ranged from .20 to .79 .

Design and Data Analysis

The study employed a 2X2(X3) mixed factorial design featuring two levels of ability (high and low), two levels of grouping (homogeneous and heterogeneous), and three types of learning (factual recall, application, and problem solving). Posttest scores were analyzed through mixed effects ANOVA procedures.

Procedures

Within the high and low ability groupings, students were randomly assigned to treatment groups. Students were told that they would be tested individually one week after receiving instruction: The treatment was then administered as prescribed. Students has one class period (approximately 45 minutes) to complete the treatment. One week after the instruction, subjects received a written posttest.

Results

Posttest Scores

The means and standard deviations for each level of the posttest are found in Table 1 and the results of the corresponding ANOVA are found in Table 2.

Insert Tables 1 & 2 about here

As expected, the overall posttest means of the high ability (61.9) and low ability (30.5) groups were significantly different, F(1,36)=17.59, p<.001. Though no significant differences were found for either grouping method or for the ability X grouping method interaction, the predicted patterns were obtained. As shown in Figure 4, the low ability subjects, grouped heterogeneously, consistently scored higher than their low ability counterparts grouped homogeneously. Further, although the high ability subjects, grouped homogeneously, achieved greater overall success than the other high ability group, the pattern was inconsistent over levels of questioning. In fact, the high heterogeneous group outscored its counterpart on the problem solving questions.

Insert Figure 4 about here

As expected, significant differences were found for both levels of questioning, F(2,72)=72.50, p<.001, and ability X levels of questioning, F(2,72)=4.17, p<.05. Post hoc analyses of the interaction of ability and levels of questioning, using Tukey tests, indicated significant (p<.05) pairwise comparisons between factual and both application and problem solving questions: Increasing the complexity of the learning task resulted in differences in group achievement. Specifically, as the complexity of the learning task increased, scores of both high and low ability groups were reduced. However, although the high ability group indicated significant reductions in achievement, the low ability group demonstrated performance scores that suggest a floor effect for higher levels of learning.

Discussion

This study examined two methods of ability grouping for cooperative learning. Although the interaction between ability and grouping method was statistically insignificant, the predicted pattern was found between the two treatments. Further analysis of these factors revealed that low ability students in the heterogeneous treatment showed a 51% improvement in learning over the other low ability group, while the high ability students in the heterogeneous group showed a 9% decrease in learning compared to the other high ability group. Stated differently, the low ability students in mixed groups showed improvement in achievement over the other low ability students, without a negative effect on the achievement of the high ability students in mixed groups. These findings tend to support previous cooperative learning studies which suggest that cooperative learning poses little risk to the more able tutors.

While the overall effect of grouping strategies appears to have little influence on high ability students, low ability students grouped heterogeneously appear to perform at higher levels than their homogeneously grouped counterparts. Further investigation of the scores of the low ability students revealed that while only marginal differences were found between the groups for problem solving, much greater variability was found at both the factual and application levels. Low ability students, with poorly developed learning and problem solving skills, may quickly model superficial strategies that enhance learning of lower level information through heterogeneous cooperative learning. However, developing more complex learning skills to assist problem solving is likely to be a much more difficult task. While learning simple information is a relatively well defined process achievable through a number of strategies, learning the skills necessary to improve problem solving is much less well understood: These skills cannot be easily trained and require gradual development (Derry & Murphy, 1986). Consequently, the development of problem solving skills is unlikely to take place as a result of limited exposure to heterogeneous cooperative learning.

No significant differences were found between the two grouping methods: This in itself may be noteworthy. There are many goals of education, other than academic achievement, that may be fostered by cooperative education such as concern for other students' well being, positive attitudes for students of different ability levels (Slavin, 1983), improved race relations (Stallings & Stipek, 1986), and enhanced self esteem for low ability students (Slavin & Karweit, 1984). Grouping strategies that promote important social objectives through mixed ability grouping, without significant decrements in academic achievement may be preferable to competitive strategies.

Several potential limitations of this study warrant discussion. One limitation may have been the lack of control over intra-group cooperation. This study included individual incentives as a means of encouraging cooperation. Some have suggested that students in cooperative learning environments perform best if given group versus individual incentives (Johnson, Maruyama, Johnson, Nelson, & Skon, 1981; Slavin, 1983). If so, group incentives might have promoted greater cooperation between group members. Although the procedures of this study encouraged cooperation, group incentives were not used to mediate cooperation among group members.

Increased incentives to cooperate are likely most critical for heterogeneous ability groups where differences in learner needs are most pronounced. In a study of ability based grouping methods, students in heterogeneous groups showed greater levels of interaction than homogeneously grouped students (Nijhof & Kommers, 1985). Group rewards may encourage higher ability students to invest more effort in advising less able students and, simultaneously, less able students may invest more effort in the process of receiving help. The resulting deeper processing would likely manifest itself in improved test scores *if* the incentives to cooperate are appealing.

In summary, this study supports the notion that heterogeneous ability grouping may have few negative consequences and significant potential for both academic and social outcomes. In addition, cooperative grouping may help to ameliorate logistical problems associated with the dearth of computers in the schools. Precisely the degree to which the potential of heterogeneous grouping is realized, however, is likely to depend more on internal group dynamics than on learning from the computer per se.

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Table 1. Posttest means and standard deviations.

Grouping strategy		Facts	Applications	Problem solving	Totals
Homogeneous					
Hi (n=10)					
	M	86.00	59.90	55.00	64.59
	SD	17.92	39.42	41.48	33.13
Lo (n=8)					
	M	57.50	8.38	16.75	23.80
	SD	26.99	12.57	19.90	14.25
Total	M	73.33	37.00	38.00	46.46
	SD	26.12	39.77	38.16	33.16
Heterogeneous					
Hi (n=12)					
	M	84.58	44.42	58.17	59.62
	SD	15.15	28.68	35.85	25.19
Lo (n=10)					
	M	77.50	25.00	19.00	35.88
	SD	20.72	17.90	21.51	15.69
Total	M	81.36	35.59	40.36	48.82
	SD	17.81	25.81	35.63	24.18
Ability					
Hi (n=22)	M	85.23	51.46	56.73	61.88
	SD	16.07	34.05	37.59	28.45
Lo (n=18)	M	68.61	17.61	18.00	30.51
	SD	25.14	17.52	20.23	15.88

Table 2. ANOVA performed on posttest scores.

Effect	df	MS	F	P
Group	1	516.00	.33	.57
Ability	1	27,620.03	17.59	.0001*
Group X Ability	1	2,259.30	1.44	.24
Error	36	1,570.25		
Levels of questioning	2	21,574.72	72.50	.0001*
Group X Levels of questioning	2	202.39	.68	.51
Ability X Levels of questioning	2	1,241.70	4.17	.02*
Group X Ability X Levels of questioning	2	695.40	2.34	.10
Error	72	297.57		

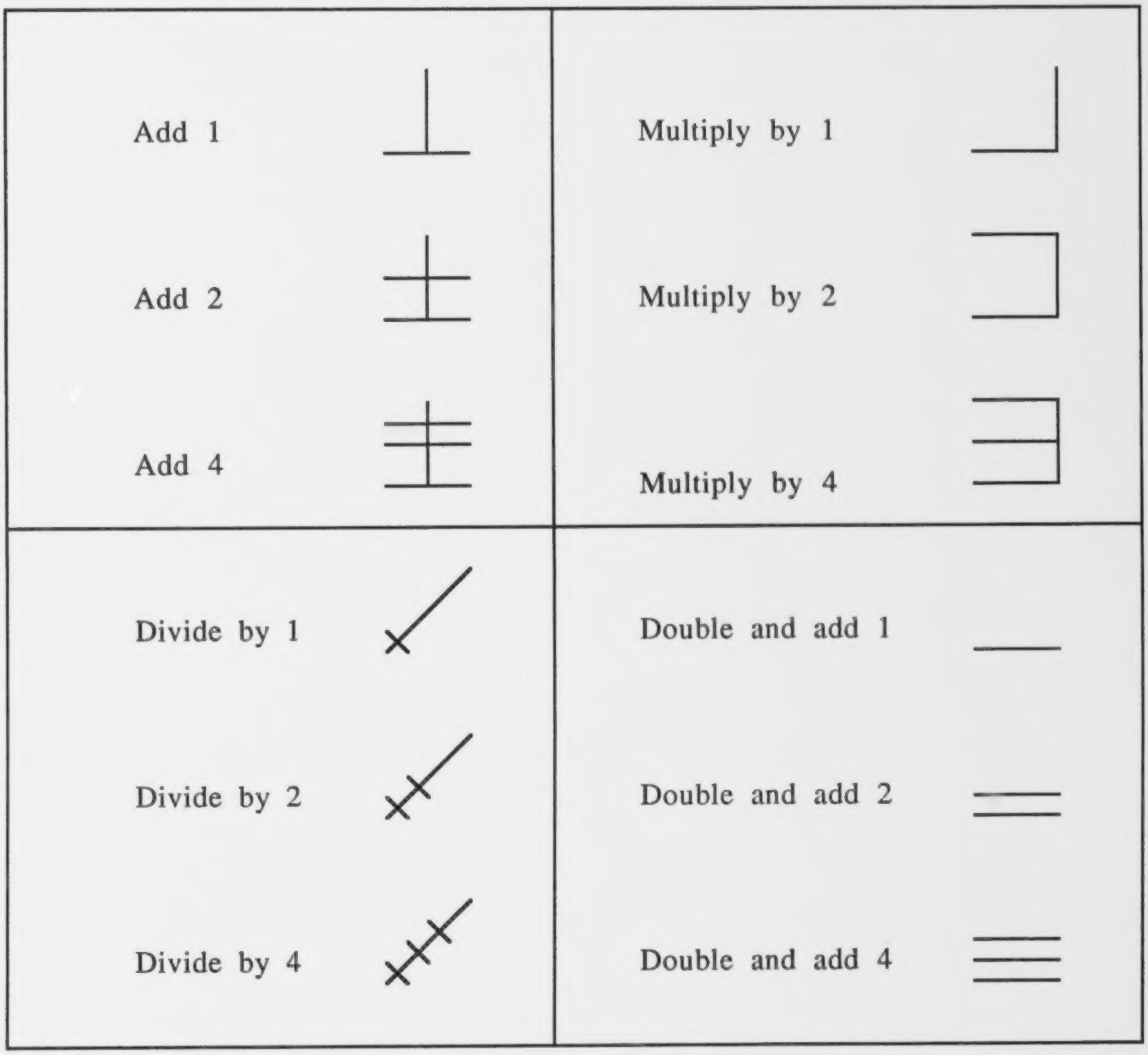
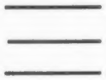
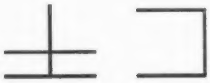

Add 1
Multiply by 1
Add 2
Multiply by 2
Add 4
Multiply by 4
Divide by 1
Double and add 1
Divide by 2
Double and add 2
Divide by 4
Double and add 4

Figure 1. Function symbols.

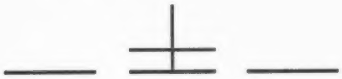
What does the symbol  mean?

a] Add
b] Divide
c] Multiply
d] Double and add.

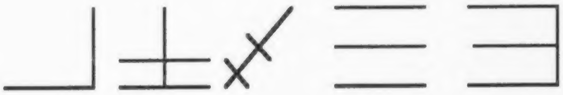
Answer: d

Evaluate the string 

Answer: 4

Evaluate the string 

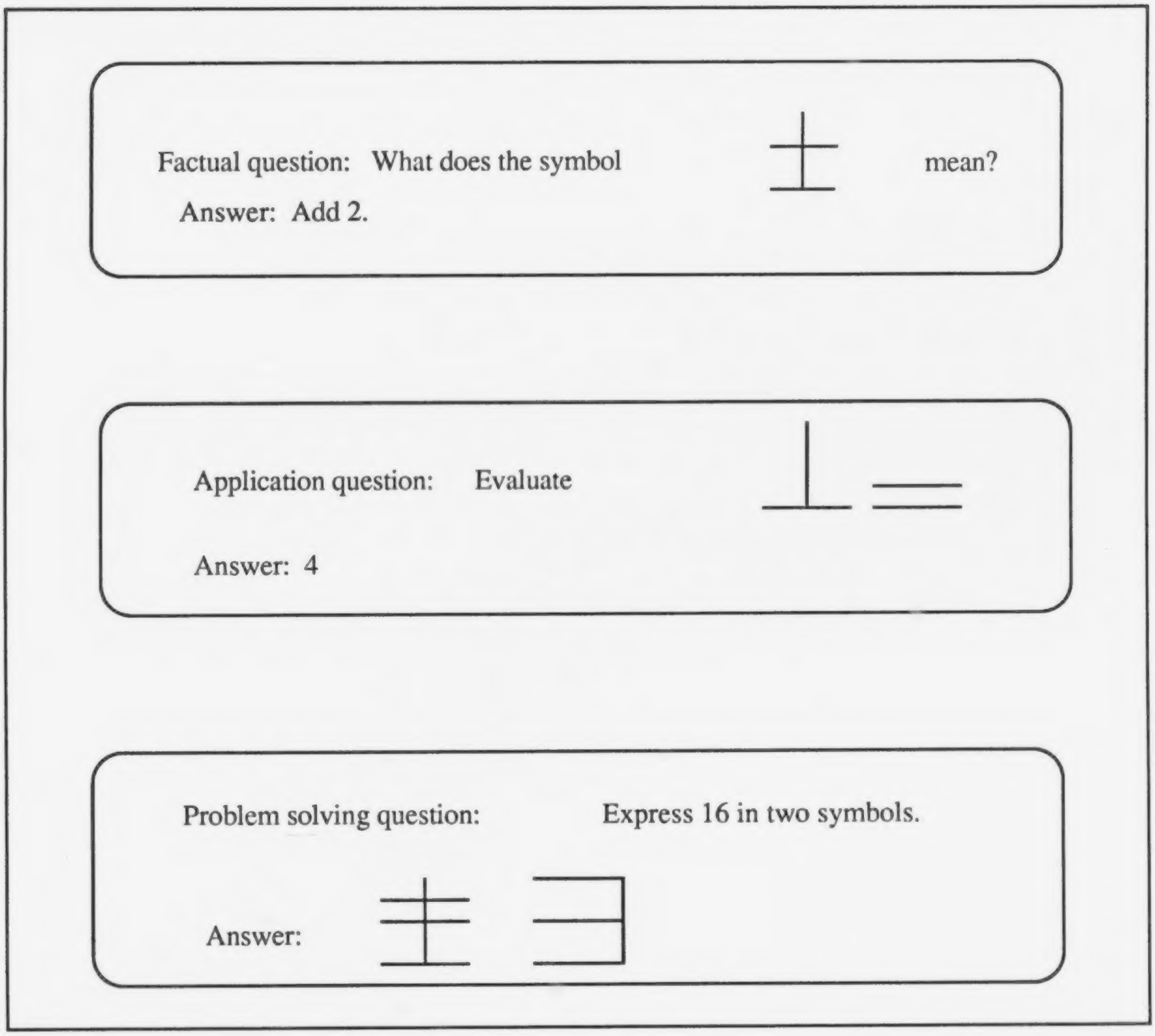
Answer: 7

Evaluate the string 

Answer: 24

Figure 2.(a-d). Examples of questions embedded in the tutorial.

400



Factual question: What does the symbol mean?

Answer: Add 2.

Application question: Evaluate

Answer: 4

Problem solving question: Express 16 in two symbols.

Answer:

Figure 3. Examples of posttest questions.

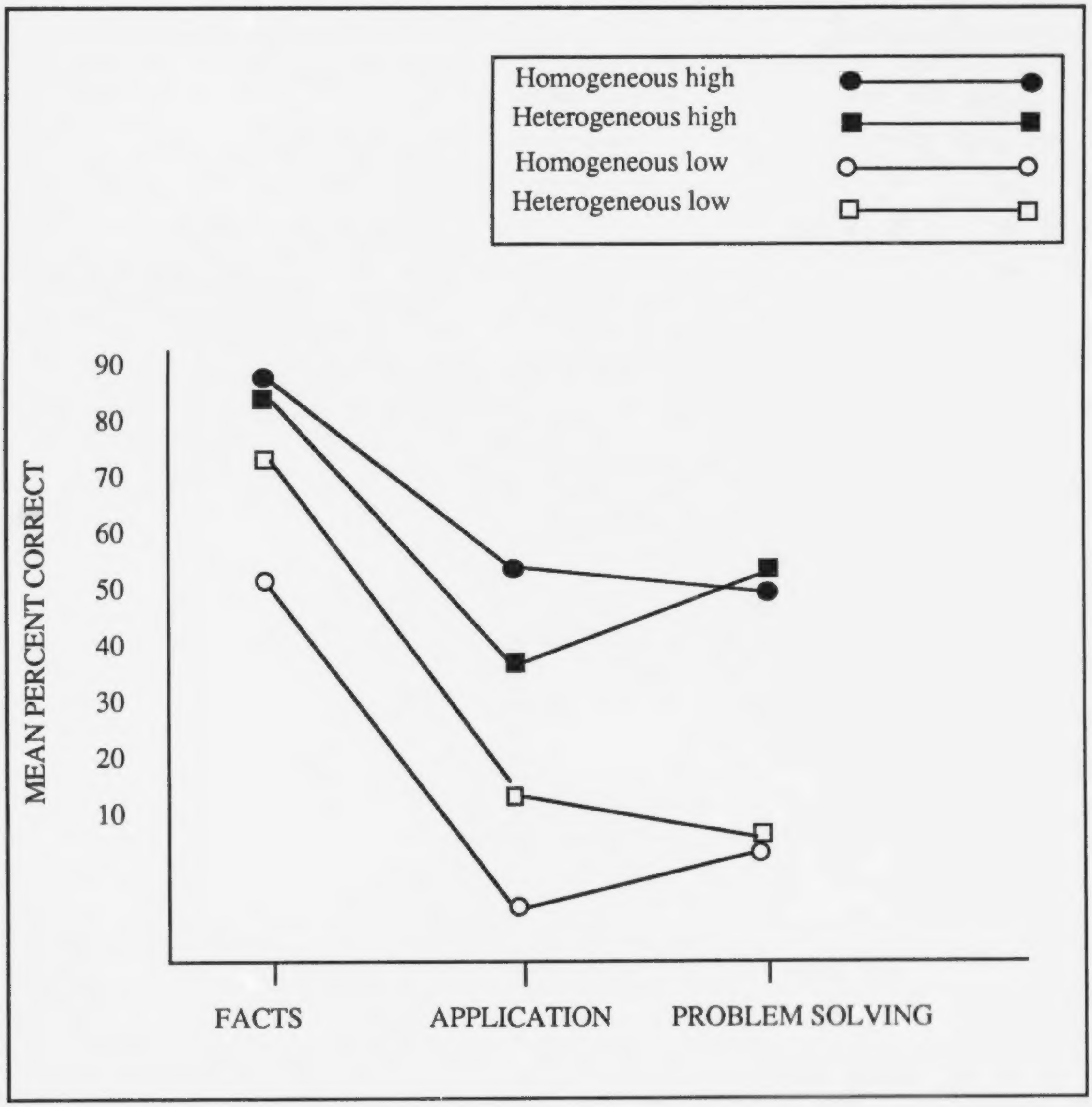


Figure 4. Percent correct for facts, applications, and problem solving.

Title:

Linking Educational Philosophy with Micro-Level Technology: The Search for a Complete Method

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Linking Educational Philosophy With Micro-Level Technology: The Search For A Complete Method

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A Paper Presented to The Research and Theory Division of

The Association For Educational Communication and Technology Conference

January 16 - 19, 1988, New Orleans, Louisiana Conference

Introduction

Traditionally educational technologists have not been concerned with social or philosophical questions. Many of the decisions made by educational technology practitioners are based on an incomplete philosophical position or a position that is held unconsciously. Furthermore, because of the dynamic nature of the field, the definition of educational technology has been in evolution. The rapidly changing definitions of the field have not provided sufficient direction to practitioners. Additional guidance may be required to aid technologists in performing their role. This inquiry will pursue the question of the relationship of educational philosophy to educational technology. The paper attempts to present a conceptual framework through which educational technologists can address the philosophical concerns that are crucial to these professionals and those that they serve. I will discuss some of the criticisms of educational technology and trace them to a common root. An analysis of the practice reveals some underlying philosophical assumptions about the relationship of technology and education. With this at hand I will discuss the importance of philosophy in addressing this issue. The development of a complete philosophy for education will be advocated and an example of a complete philosophy of education will be reviewed. The conclusion will point out some of the opportunities for future inquiry into this issue.

This working paper is by no means exhaustive.[1] Issues of instructional technology or educational technology for the purposes of training and development in industry and the military are not considered. International settings are not taken into account. I am confining this discussion to American society because I am part of it, and it is more familiar to me than other societies. This does not exclude the application of this discussion beyond an American setting. However, this must still be researched.

Criticisms of Educational Technology

There are many criticisms of the field of Educational Technology. One of the main criticisms of technology as it is applied to instruction or education is that the technologists fail to concern themselves with the social and philosophical issues that are involved in the process of education. The literature suggests that these criticisms are often justified.

Social and philosophical critiques of educational technology have been classified in a number of different fashions. Three major categories of criticism are:

1) that it is dehumanizing, (Freire, 1970; Rogers, 1983; Apple, 1982);

2) that it fosters and sustains the ideological positions of the dominant factions of society, (Apple, 1979; Kleibard, 1977a);

3) that it perpetuates further dependence on technology, (Hyman, 1973; Hyman, 1974).

A number of lines of inquiry could be used to analyze these social and philosophical criticisms as they relate to educational technology, but time and space will not permit such an exhaustive study.

Since it appears that these stem from a common root, one can readily identify the criticisms of educational technology in this regard. This root, a common denominator for many of the social and philosophical criticisms of this field, has been called "Technicism" (Stanley, 1978) and "Technical Rationality" (Schon, 1983).

Manfred Stanley (1978) describes technicism as reflecting a particular attitude toward the relationship among science, technology, and human consciousness. Technicism is not a deliberate philosophical position. It is the antithesis of an intentionally evolved position. It is a view of the world based on "unconsciously taken for granted assumptions" that are the result of a "historical and cultural process rather than an individual or collective intellectual decision" (Stanley, 1978 p. 10). While Stanley discusses a number of ways to interpret technicism, his inquiry focuses on what he calls "pantechnicism" which he defines as "a view of the entire world being symbolically reconstituted as one interlocking problem solving system according to the dominate technological language of control" (Stanley, 1978 p.10).

Donald Schon (1983) uses the term "technical rationality" in very much the same way that Stanley uses "pantechnicism." Schon writes: "From the perspective of technology rationality, professional practice is a process of problem solving. Problems of choice or decision are solved through the selection of available means of the one best suited to the established ends. But with this emphasis on problem solving we ignore the setting, the process by which we define the decisions to be made, the ends to be achieved, and the means which may be chosen." (p. 39-40). Technical rationality is a form of technicism.

It is important to point out that neither Schon nor Stanley view technology or science as inherently evil. Their discussions focus on the assumptions (explicit/implicit) held by the individuals who investigate science and use technology. The model that currently dominates the investigation for educational technology is the systems approach (Fleshig, 1975). One might conclude that the systems approach that is used by many educational technologists is the target of this criticism. However, the inquiry into technicism reveals that there are other assumptions held by educational technologists that are questioned as well, particularly in the area of philosophy of science.

Technicism has as its base the philosophy of science known as positivism. This approach is based on three major assumptions:

1) that science, not philosophy, is the means for attaining knowledge;

2) that science, in practice, is the act of observing; and

3) that science and technology themselves are value neutral (Flew, 1979).

While all three are important to analyze, it is the third, that science and technology themselves are value neutral, which is particularly important to this paper.

Technicism is the root of the criticisms of educational technology. The assumption is that science and technology are value-neutral and therefore are not expected to transfer values. Technicism holds that only content is being transferred. Information transfer is the goal of technicist thought. Technicism holds that outcomes of utilizing technology are dependant on the intent of those that plan the use of technology. This conception ignores the possibility of a hidden curriculum. It is the failure to fully analyze the values that are implicit in the use of technology in education that opens the door for the accusations of dehumanization and the perpetuation of ideological and technological dependence that is then passed on to learners. Educational technologists must take up the question of what happens beyond their planned intentions and actions.

It is the belief held by some technologists, that technology and science are value neutral, that seems to be most problematic to critics of educational technology. An analysis of the literature show that the hidden curriculum, a mode of transferring values and assumptions, exists within our present educational system. (Jackson, 1968; Apple, 1977, 1979, 1983; Kliebard, 1977A, 1977B; Hyman, 1973, 1974; Rogers, 1969, 1983; Olds 1985; Silberman, 1970; Gerbner, 1974; Young, 1971, 1973; Vallance, 1974).

There has been little agreement among educators as to a definition of the hidden curriculum. The literature concerning the hidden curriculum extends in many varying directions. Several doctoral dissertations have attempted to categorize this literature and ultimately define the hidden curriculum. (Cowell, 1973; Weidemann, 1973; Bain, 1974; King, 1976). It is important to note that while there is some disagreement on definition there is agreement among educators that a tacit transfer of values does occur in our schools.

There are important considerations involved with the existence of the hidden curriculum for educational technologists. As Marshall McLuhan so aptly put it: "We are too concerned with using technique rather than considering the implications of technique" (1962, p. 19). Wilber Schramm followed with a sobering observation: "They can learn what they are intended to learn and also what they are not intended to learn." (1977, p.32). Schramm indicates the possibility that students may acquire undesired knowledge and skills.

Depending on the goals of the educational system, the values that are transferred may prove to be functional or dysfunctional. Dreeben (1968) provides a very positive view of the hidden curriculum and its usefulness in the schools and to society. He focuses on the structural characteristics of schools and how this structure fosters socially desirable norms. Pappert, (1980) outlines some steps for the development of a positive hidden curriculum in a computer-based education system. He emphasizes intellectual skills and the natural growth of the learners.

It would seem reasonable to believe that there are always both positive and negative aspects of a hidden curriculum in any educational system. It would seem equally reasonable to state that the analysis of the hidden curriculum should be a priority for educational technologists. There are opportunities to create meaningful learning experiences for students. The experiences need not be side effects of designed expository instruction. They can be designed so that the content of the particular lesson is subordinate to the process or the hidden curriculum of that lesson. However, this has not often been the case.

One reason why this problem of value transfer faces educational technology is the lack of guidance provided the professionals of the field by the very definition of the field. In a period of less than eight years the definition of the field has been altered such that educational technology has become, on paper, indistinguishable from definitions of 'instructional technology,' 'instructional development,' 'educational research,' and 'curriculum development.'

In 1970, the Presidential Commission on Instructional Technology defined instructional technology in two ways.

> First, "In its more familiar sense it means the media born of the communication revolution which can be used for instructional purposes along side the teacher, the textbook, and the blackboard...the pieces that make up instructional technology: television, films, overhead projectors, computers, and the other items of hardware and software.
>
> Second, and less familiar definition of instructional technology goes beyond any particular medium or device. In this sense instructional technology is more that the sum of its parts. It is the systematic way of designing, carrying out, and evaluating the total process of learning and teaching in terms of specific objectives based on research and human learning and communication and employing the combination of human and non-human resources to bring about more effective instruction."

The Association for Educational Communication and Technology in 1972 had defined educational technology as follows:

> "A field involved in the facilitation of human learning through the systematic identification, development, organization, and utilization of a full range of learning resources and through the management of these processes. It includes, but is not limited to the development of instructional systems, the identification of existing resources and the management of these processes and the people who perform them."

The definition of educational technology as put forth by the Association for Educational Communication and Technology in 1977 states:

> " Educational technology is a complex, integrating process involving people, procedures, ideas, devices, and organization for analyzing problems and devising, implementing, evaluating, and managing solutions to those problems involved in all aspects of human learning."

The practice of educational technology does not occur in a vacuum. Though not mentioned in any definitions, technology takes place in a socio-political environment directed toward specific goals. There are value implications tied to the definition of the field. There is value attached to each word in each definition. For example, the use of the words "development" and "management" have connotations which may be as completely unacceptable to some educationists as theY are absolutely necessary for educational technologists. As values (explicit/implicit) change the definition of the field is likely to change.

A broad definition of the field need not be an insurmountable obstacle to the practice of technology by educationists, as long as we are aware of what values are implied. Personally, I welcome the opportunities that accompany a less structured field. It would seem logical, however, that as the definition broadens and provides less structure for the specifics of the practice that something else is needed to aid in the direction of the field. I would propose that a conscious philosophy be considered to help guide the practice of educational technologists.

Toward A Philosophy of Technology

There is nothing mysterious about developing a philosophy. Judge Benjamin Cardozo, (1921) pharaphrases William James as having said that:

> "Every one of us has in truth an underlying philosophy of life, even those of us to whom the names and the notions of philosophy are unknown and anathema. There is in each of us a tendency, whether you choose to call it philosophy or not, which gives coherence and direction to thought and action."

It would seem that all of us hold a philosophy. A value clarification exercise would reveal a number of values and philosophical principles that are within each one of us. The level of sophistication and the level of awareness of this philosophy might vary with each individual. While some might disagree with me, I do not believe that developing a consciousness about philosophy requires a high degree of technical skill. Further, it need not be reserved for those who hold graduate degrees. Do not infer that I am making light of such an enterprise; it is not an easy task. I believe it to be among the most important undertakings to which an individual can aspire. All people make value judgements. Few make a serious attempt to consciously develop a philosophy. Fewer still persevere and continue the questioning.

A conscious philosophy is generated as a result of one's need to understand and explain natural, social, and/or personal conditions. It will also act as a guide for one's actions and aspirations. Most people are enculturated into various philosophical frameworks which serve to direct their lives. To truly develop a philosophy one must search beyond the conceptions and assumptions that are currently held. A reflective self analysis is required. This investigation and/or formulation of alternative positions is a continual process based on the experience and reflection of the individual.

This constant "reconstruction" (Dewey, 1920) of thoughts and ideas of philosophy may be the reason for the popular belief that one may hold a particular philosophy and that one may do philosophy. To be sure, not all philosophers would agree with Dewey's assertion that "doing" philosophy and "holding" philosophy are the same thing. I will follow Dewey's lead and proceed with the assumption that there is an unnecessary dualism between these concepts, "doing" philosophy and "holding" philosophy. It is believed that the values implicit in ones actions, that which one does, are the same as one consciously believes, that which one holds. The actions one takes may be interpreted as expressing a held belief. If one is consistent between actions and belief, then philosophy is both a means and an end.

The question arises, "Why philosophy as a guide to practice, why not theory?" Victor Farganis (1975) states there are values implicit in any of the social sciences. Education may be considered a social science. These implicit value considerations are what give a particular theory or a conception meaning and prevent it from acting as a neutral vehicle. In short, theory is value laden. When theory is put into practice it is a philosophical act. Regardless of the intentions behind the act, values are articulated and may be transferred.

Education is often oriented to practical activity. Technologists often make decisions based on practical experience, but also based on their values (explicit/implicit).Practical experiences cannot provide them with the escape from an essential principle. "That principle addresses itself to the question of what we ought to do when we teach. This is particularly important in a technological society where the relationship between knowledge and human affairs is often obscured", (Kliebard, 1977b, p. 34). What "is" should not modify what "ought" to be. The present state of technology should not necessarily modify the goals and values of education. The state of practice should be made consistent with the goals and values of education.

Every human activity presupposes values that are essential to that activity. "Science, for example, presupposes the worth of knowing those things that science discovers. If you deny the proposition that these things are worth knowing, then there is no sense in doing scientific work" (Magee 1971 p. 147). The same can be said for technology as the application of science (Romisowski, 1981). It too presupposes values. From there it would follow that educational activities assume some principles and values that must be accepted if you are going to seriously consider them. These principles or values fall into two groups; those that are about the discussion of the school as an organization and its curriculum content and those that are concerned with ideas of teaching and learning. For example, the existence of school administrative systems presupposes that an authority structure is indeed worth having.

We need to spell out all of the elements pre-supposed by our actions. To paraphrase Socrates, unexamined education is not worth doing. Socrates concluded that few people really bother to undertake the inquiry necessary to know what they were about. Such might be the case with technists.

There are two major advantages in wanting to be clear about what one is trying to do. First is that, upon further examination it may turn out that one may not be doing what one really intends to do. Such self examination of educational efforts may suggest changes that could result in a more desirable type of educational technology than is currently practiced. The second, is that such an examination will enable practitioners to enter into discussions about their practice. The dialogue that should follow is bound to improve the quality and quantity of the wisdom and knowledge that goes into education and educational technology.

A value analysis must be undertaken. This can only be approached through a conscious effort by practitioners and researchers. But this clarification is never finished. As technology and education change at all levels, it would seem that the whole enterprise must constantly be re-examined. Since the central questions of instructional or educational technology are actually value questions, a philosophy which could function to help guide this practice would be of considerable help.

It is imperative for students and for society as a whole that practitioners in educational technology know and understand the idea of what it is they are doing and perhaps more important, why they are doing it.

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Again, Dewey, (1938a) says:

> "the difference between educational practices that are influenced by a well thought out philosophy and practices that are not so influenced is the difference between education conducted by some clear idea of the ends in the way of ruling attitudes of desire and purpose that are to be created and an education that is conducted blindly under the control of customs and traditions that have not been examined or in response to immediate social pressures." (p. 99).

Investigation into the conduct of educational practice should result in the beginning of an inquiry into the hidden curriculum. It is also a step toward identifying and understanding the technicist assumptions.

An Alternative: A Complete Philosophy for Education

It seems reasonable to think that the paradigm of wholes, that is system theory, (Bertalanffy, 1968) should be guided by a complete philosophy. The complete philosopher will not only analyze in the ways that have been described in languages and values, but will also speculate about the world as a whole; about goals, norms, and human experience providing some guide to action.

William Frankena provided a useful mapping of a more complete philosophy in his book Philosophy of Education (1965). In that book he identifies five points:

a) a statement of basic ends or principles of ethics and social thought

b) (empirical and other) premises about human nature, life, and the world

c) a list of excellences to be produced

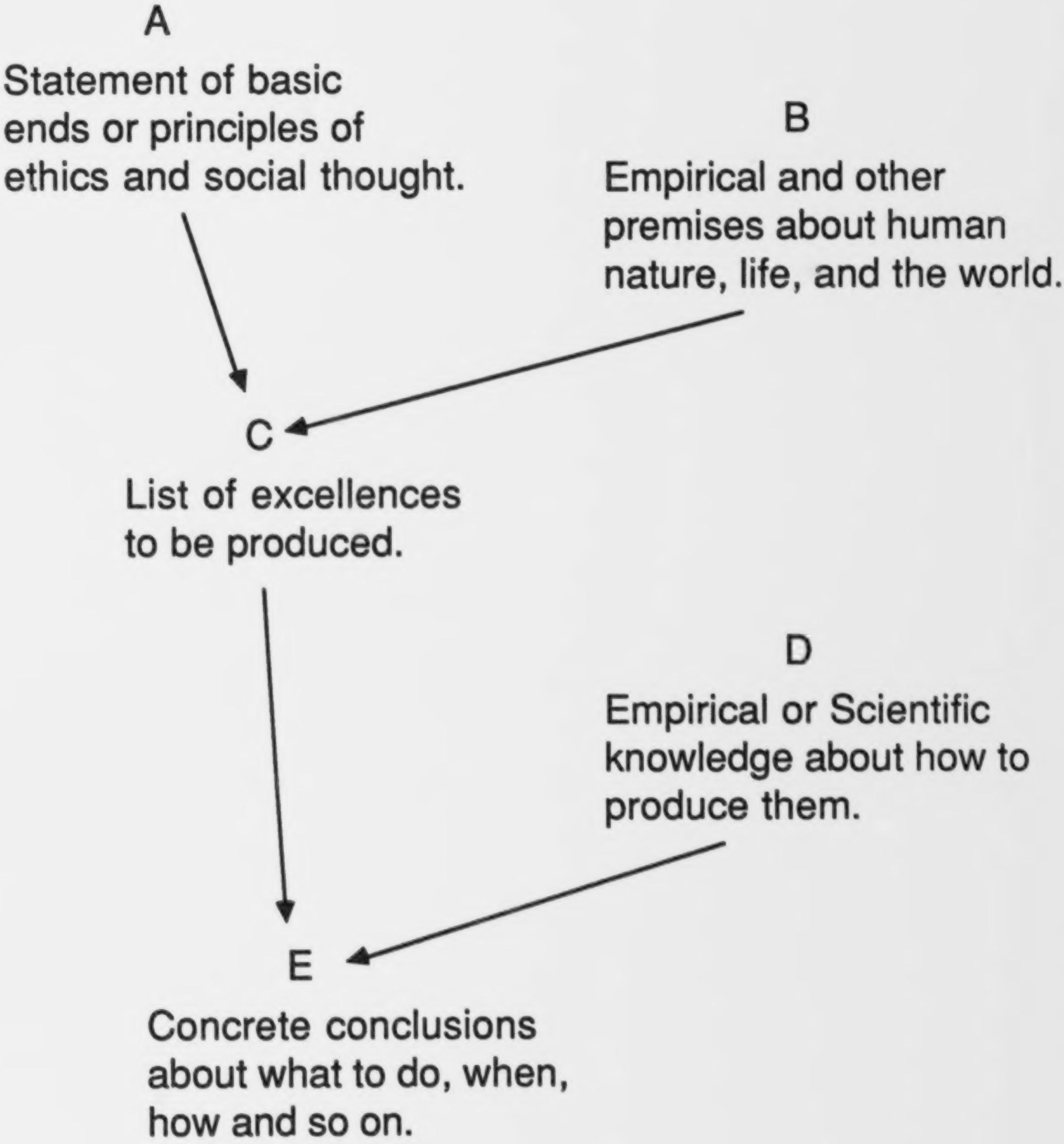
d) scientific knowledge about how to produce them

e) concrete conclusions about what to do, when, and how, and so on.

Frankena explains his overall outlook:

> "Education is the process by which society makes of its members what is desirable that they should become... either in general or in so far as this may be called 'schools'." (p. 95).

Frankena's steps to guide practice are most useful. Magee (1971) outlined Frankena's map (figure 1) and describes Frankena's work as follows:



A

Statement of basic ends or principles of ethics and social thought.

B

Empirical and other premises about human nature, life, and the world.

C

List of excellences to be produced.

D

Empirical or Scientific knowledge about how to produce them.

E

Concrete conclusions about what to do, when, how and so on.

William K. Frankena (ed). Introduction to Philosophy of Education. New York: Macmillan, 1965 quoted in Philosophical Analysis in Education. Magee 1971. p.45.

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> "With this as a frame of reference, he sorts out the desired levels of knowledge that function as our guides to decision making in practical educational affairs. Conclusions at E (judgements about what to do) are a mixture of judgements about the "excellences to be produced" (C) in the beneficiaries of the educational process, combined with "emperical or scientific knowledge about how to produce them" (D). It is important to notice that we cannot derive the list of prescriptions, excellences, that are a set of value judgements about what to do, from the descriptive, empirical, knowledge accounts of what the facts actually are. It is, in short, not possible to go directly from scientific understanding to policy and practice. Practice is always a combination of prescriptive convictions and descriptive understanding.
>
> Going back up the ladder, we can see that C, the list of excellences, is itself a judgment based upon a judicious combination of A, our presuppositions of the basic ends of life and the fundamental principles of right action and right social organization, and B, or presuppositions concerning human nature, life, and the world. This latter concept is itself complex, consisting not only of the empirical or common sense facts about nature, life, and the world as we believe them to be, but also our ultimate presuppositions about existence, our metaphysical beliefs, and existential commitments. These latter can include such notions as belief in God or a naturalistic rejection of such belief.
>
> We can summarize this ladder by saying that E, our concrete conclusion about what to do, presupposed judgments about values (C) and empirical claims (D). C in turn presupposes our ultimate convictions about values and moral principles (A) in combination with our presuppositions, empirical and otherwise, about human nature, life and the world." (Magee, 1971)

When determining a personal or organizational philosophy about the use of technology one must try to be clear about the inter-relationships of the different aspects of philosophy and how they relate in the educational process.[3] Frankena has demonstrated the relationship of theory and practice. Magee has done a marvelous job of explaining the relationships described by Frankena.

I would agree with Frankena that the driving force behind a complete philosophy of education is a social philosophy, a sense of social vision. I would also agree that social philosophy in combination with epistomological and metaphysical concerns play a major role in forming the ethics of a society. But Frankena's approach seems to be a bit too hierarchical. It appears to deny interaction among the varying aspects of philosophy. I believe that any one aspect of philosophy can effect another and there is a more interactive and equal relationship among them than is portrayed in the Frankena model. My point is that a complete and philosophical construct is not necessarily a hierarchial one.

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Certainly there is a driving concept but that driving concept is subject to change based on the influence of other aspects of the philosophy at various points in time. In this conception of educational philosophy both philosophical analysis and axiology are relevant concerns at any point during the discourse.

We have seen in the representation of Frankena's "ladder" an attempt to formulate a complete philosophy for education and educational practice. I believe the ladder analogy is a convenient way to visualize the relationship of the various aspects of philosophy to practice and hence is a useful framework through which educational technologists may analyze and develop their practice. However useful this conception is, I find myself feeling that it is not totally accurate.

It is incomplete for two reasons. First, it does not fully represent the thoughts involved in axiology and it seems to ignore the aspect of aesthetics. It has been said that axiology is intertwined with metaphysics and epistomology to the point where the discussion of one leads to an implicit discussion of the other (Koettig, 1983). Frankena seems unwilling to try to separate them. I would fully agree that the three are intertwined and a discussion of one in isolation is next to impossible. Throughout this paper I have emphasized the importance of values and value transfer in the practice of educational technology. I have said that value transfer is the basis for analyzing the hidden curriculum. Value reflection is an activity that is aimed at identifying our presuppositions. For those reasons I would like to emphasize axiology. In the educational endeavor, value inquiry merits a special attention. As a socially construed institution, education is more concerned with issues of value than it is with conceptions of knowledge and reality.

Exclusion of aesthetics from "Frankena's ladder" is a value decision as is my decision to include it. I choose to include it for two reasons. The first is that teaching is an art (Dewey, 1928). The application of science is technology; the application of technology is an art. The second reason is derived from reflection on the field of educational technology and its possibilities in practice. McLuhan (1964) states: "The artist is the man in any field, scientific or humanistic, who grasps the implications of his actions and of new knowledge in his own time." (p.51).I hope that the increased awareness will contribute to the art, the practice of Educational Technology.

Another reason I believe that "Frankena's ladder" is incomplete is that it does not attempt to show the relationships among the differing aspects of Philosophy beyond epistomology, metaphysics, and axiology. I am left with the impression that Frankena does not represent these relationships and does not feel that it is necessary to acknowledge them. The ladder is not unlike a simple algorithm. It is similar in style to many of the models that educational technologists use to represent design and development processes. I do not wish to characterize Frankena as a technicist philosopher, but I think that we have seen that there are relationships between all of the aspects of a complete philosophy.

I should like to point out that this is not the only way to conceive of a complete philosophy of education. There is certainly no one "right" way to do this sort of inquiry. The ideas represented in both the frameworks for a complete philosophy for education are the results of an exercise in logic. In

Frankena's case the social ideal is conceived and then a framework is developed to achieve that ideal. It is important, but not essential that this model identifies a social vision as its aim. This need not always be the case. Conceivably one could develop in the direction of ethics or some other philosophical aspect of education. One advantage to using the complete philosophic framework is that it should serve to reduce the negative side effects of the hidden curriculum. With proper analysis of the concept and possibilities of educational outcome, technologists may be able to devise a process, a hidden curriculum, consistent with their social vision and that of their clients. But this can only be done after a complete philosophical inquiry has been undertaken.

Questions For Future Inquiry

One question that was raised in writing this paper is, "Given this new context from doing educational technology within an educational philosophy, what might a new definition of the field look like?"

Other possibilities include a dialogue on the development of social, ethical, and educational aims. This is certainly a conceptual inquiry and research as to what and how these aims need to be identified and advanced.

Further conceptual analyses of the "factors" of our field would be most welcome, other implicit values and assumptions must be identified. This would certainly be necessary and desirable before we begin to move in the direction of social philosophy. Failure to do so could very well result in something less desirable that we have in current practice.

Another possibility for future research includes the development of a philosophy of science for educational technology. To date, we have seen in the article by Ely, (1970) "Towards the Philosophy of Instructional Technology", a movement away from a physical science concept of technology. I am aware of other works in the area of philosophical inquiry into technology (Becker, 1977; Koetting, 1981; and Lukowski,1981). A philosophy of science for our field must include aspects of communications theory as well as phenomonology and hermeneutics. It would synthesize ideas from the behavioral science concept, the physical science concept and the mass communications concept, into a social science concept of educational technology. This view should prove to be more conceptual and more naturalistic in practice but this certainly would not lead to the demise of the field. The current paradigm shuns the premise of general system theory that the whole is greater than the sum of its parts. At present it seems as if we are somewhat inconsistent in the way we do our inquiry based on the model we use to conduct our practice.

Egon Guba and John Clark (1974) have suggested three criteria: completeness, balance, and realism by which to assess conceptual structures. I would recommend that this assessment tool be used to analyze the model I have proposed and the component parts of that model as they are further developed.

Finally we must investigate the side effects or potential persuaders in the hidden curriculum. The idea of investigating what are positive and what are negative aspects of the hidden curriculum in relation to current practices is desirable. Again, educational technology must look within itself. Such powerful influences on educational practice cannot be ignored. It must be remembered that even when practitioners and researchers investigate technicism, they are still actors involved with institutions that perpetuate it.[4]

Endnotes

[1] The author is interested in contributing to a dialogue on issues involving philosophy and educational technology, and welcomes any comments on this draft.

[2] I will use the term technicism in order to be consistent and eliminate any confusion for the reader that may come about because of multiple terms.

[3] I believe that there are nine aspects of philosophy that should be considered when thinking about education and technology applied to education. There are a number of definitions of any of these philosophical aspects but I will provide a brief statement of what it is that I mean by these terms. The

1) Social Philosophy - a comprehensive vision about how society ought to be.
2) Ethics - a set of moral positions which are consistent and acceptable in relation to the social philosophy.
3) Aesthetics - the study and assumptions that guide the inquiry and interpretation of art. One might study art in terms of the management of technology as applied to education.
4) Philosophy of Science - the study and assumptions that guide the inquiry and interpretations of the disciplines. For purposes of this paper it will also include the philosophies of history, mathematics, and law.
5) Philosophy of Mind - the study and assumptions that guide the inquiry and interpretation of the process of thinking, reflection, and imagination.
6) Metaphysics - the assumptions that attempt to characterize existence or reality in its entirety. For purposes of this paper it will be considered as inseparable from epistomology.
7) Epistomology - the study and assumptions that guide the inquiry and interpretation of the nature and purview of knowledge.
8) Axiology - the study and assumptions that guide the inquiry and interpretations of value.
9) Analytic Philosophy - the study and assumptions that guide the inquiry and interpretations of the logic of language.

[4] I would like to acknowledge those who assisted in the preparation of this version of the paper. There are many who contributed. Specifically I would like to thank Alice Berg, Salvu Chircop, James Cox, and Rob Pearson. Thank you.

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Title:

Developing a Cognitive Map of Research and Theory in Instructional Systems Technology

Author:

David H. Jonassen

DEVELOPING A COGNITIVE MAP OF RESEARCH AND THEORY IN INSTRUCTIONAL SYSTEMS TECHNOLOGY

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Paper presented at annual convention of the
Association for Educational Communications and Technology
New Orleans, Louisiana, January 17, 1988

INTRODUCTION AND PURPOSE

As researchers in the field 'of instructional systems technology, we are often called upon to answer such queries as: What is research in instructional technology? How does it relate to existing theory in the field? We are familiar with our own research interestsand the theory that supports it. But what about the big picture? Is their a model or theory of reseach in your field? While we can discourse readily on the historical development of our research, from evaluative comparison studies through attributes of media studies to information processing and intelligent systems research, can we identify and construct an appropriate schemata for research in our field? Just what is our knowledge domain?

Our knowledge domain consists of a coherent set of concepts that we use to identify our field. Just as concepts are combined by relationships to form principles, our field cannot be described by its concepts alone. Rather, our knowledge domain consists of both schemas or ideas in addition to structural knowledge. Structural knowledge describes the interrelationships between ideas in our knowledge domain. The problem is how to operationalize structural knowledge.

IST researchers usually define the domain of their own research adequately in terms of existing theory. That is, their cognitive structures for IST research and theory is comprised mostly of research on which they have worked and its supporting theory. The individual's knowledge base enables him or her to build new knowledge strucures, make inferences, solve problems, and so on (Norman, Gentner, & Stevens, 1976).

The best way of depicting these knowledge structures is by constructing cognitive maps (Jonassen, 1987; Shavelson, 1985). Cognitive maps describe the the associative structure of constructs stored in memory. They are based upon the concept of semantic proximity of constructs, which assumes that we can represent the (semantic) proximity of ideas in memory in terms of geometric space. Cognitive maps are produced from measurements and interpreted as abstract representations of one's knowledge of subject matter content (Shavelson, 1985). The measurement of cognitive representations of subject matter structures permits us to examine the list of constructs associated with any construct, the overlap between those constructs, and the relationships between pairs based upon that overlap. The simplest method for constructing a cognitive map is to rank the degree of similarity between concepts. Statistical procedures like MDS, cluster analysis, or principal components analyze the underlying structure of the intercorrelation matrices to produce a map of the knowledge domain in which the geometric distances between each of the concepts on the map represents the semantic distance between those concepts in memory.

The purpose of this study is to generate such a map which can serve as a definition of a schemata for IST research. The study seeks to define the structure of research and theory in our field by generating a "cognitive map" of the concepts or schemas that define it. Using the technique defined by Diekhoff and Diekhoff (1982), the primary set of concepts in IST research were compared for similarity with all of the other concepts in a pairwise fashion, with the structure defined by the intercorrelation matrix of similarities. The structure was mapped to provide "the big picture".

METHOD

Participants

Participants were selected from the members of the Reseach and Theory Division (RTD) of the Association for Educational Communications and Technology. This membership is the group most concerned and involved with research and theory development in the IST field.

Instrument

The first task was to identify the most important constructs or schemas in the IST research field. Three sources were used. First, a study of research interests of the membership, recently conducted by the division, identified 107 topics in research and theory development in the field. Second, a review of titles, headings, and keywords from the nine volumes of Educational Communications and Technology Journal generated 126 terms. Third, the ERIC thesaurus of descriptors produced 130 related terms. This list was first edited for redundance. Next the total list was edited using the following criteria for inclusion:

* generality (universality) of the term
* recognizability by researchers
* redundance (elimination of redundant or duplicative terms)
* relevance to the field of IST theory/research
* criticality to the field - importance of the concept to research
* communicability to related fields of research

After editing, the final list comprises 126 terms (see Table 1). These terms represent, according to the above criteria, the key concepts or schemas that define research and theory in IST.

Part 1: The first part of the survey listed the 50 concepts and asked the participants to rate on a 1-9 scale the importance of each term to the field of IST research and theory. The list was generated by a BASIC program which randomly selected the items from the whole list.

Part 2: A BASIC program was written to generate the second part of each survey. This part consisted of a 100 pairwise comparisons of randomly selected concepts from the final list. For each pair of concepts, the participant was asked to rate on a 1-9 scale the degree of similarity or relatedness between the terms in each pair. Item sampling was initially done from the entire list. Because a pairwise comparison of all 126 terms would require 7875 comparisons and adequate sampling could not provide multiple responses to each cell, the 35 most important concepts were selected from the Part 1 of the responses. These concepts are underlined in Table 1. These concepts were then completely sampled, forming a 37X37 matrix.

RESULTS

Analysis

The importance ratings from Part 1 of the survey are underlined in Table 1. The responses to the pairwise comparisons of those 35 concepts were aggregated by pair in a matrix. The final cell value for each comparison consisted of the modal value. If no mode was obvious, then the means for each pair were calculated. These values for each comparison formed an 35X34 similarity matrix which was analyzed using non-metric multi-dimensional scaling (MDS).

The MDS analysis was performed using two, three and four dimensional solutions. The four-dimensional solution accounted for the greatest amount of variance, SStress=.195, R squared=.54. This was a significant improvement over the two-dimensional solution, which accounted for only 34% of the variance. The high stress, as reflective of the unaccounted variance, probably resulted from the fact that the comparisons were based upon the perceptions of several people. In order to reduce that variance, an individual differences model of ALSCAL MDS program would have to be used. That would require several people filling completeing 1190 comparisons for the smaller matrix and 7850 comparisons for the full matrix. Stress could also be reduced by adding additonal dimensions.

The plot for the two dimensional solution is presented in Figure 1. The multiple plots for the four dimensional solution are available upon request. Interpretation of multiple dimensions is problematic. In two-dimensional space, four clusters appear to have formed: learning psychology, instructional message design, instructional design, and a types of learning. Both dimensions appear to represent a learning theory into design practice continuum. Dimension 1 represents a learning type into message design. Dimension 2 is information processing into instructional design dimension.

Discussion

It is obvious that any network description of research and theory in our field is multi-dimensional. It is a multi-faceted field. Using the two-dimensional solution, the MDS solution describes a two-dimensional theory-into-practice orientation, which describes research and theory in the field. Instructional technologists are theory-into-practice scholars for the most part. We generate applied research. An analysis of the multi-dimensional solutions may suggest more intellectual dimensions.

In order to produce complete results, much more data needs to be collected and analyzed. That logistics of such a project are far more problematic than anticipated. This has become a pilot project of sorts. If possible to complete a final project, we should be able to empirically generate a conception of our field.

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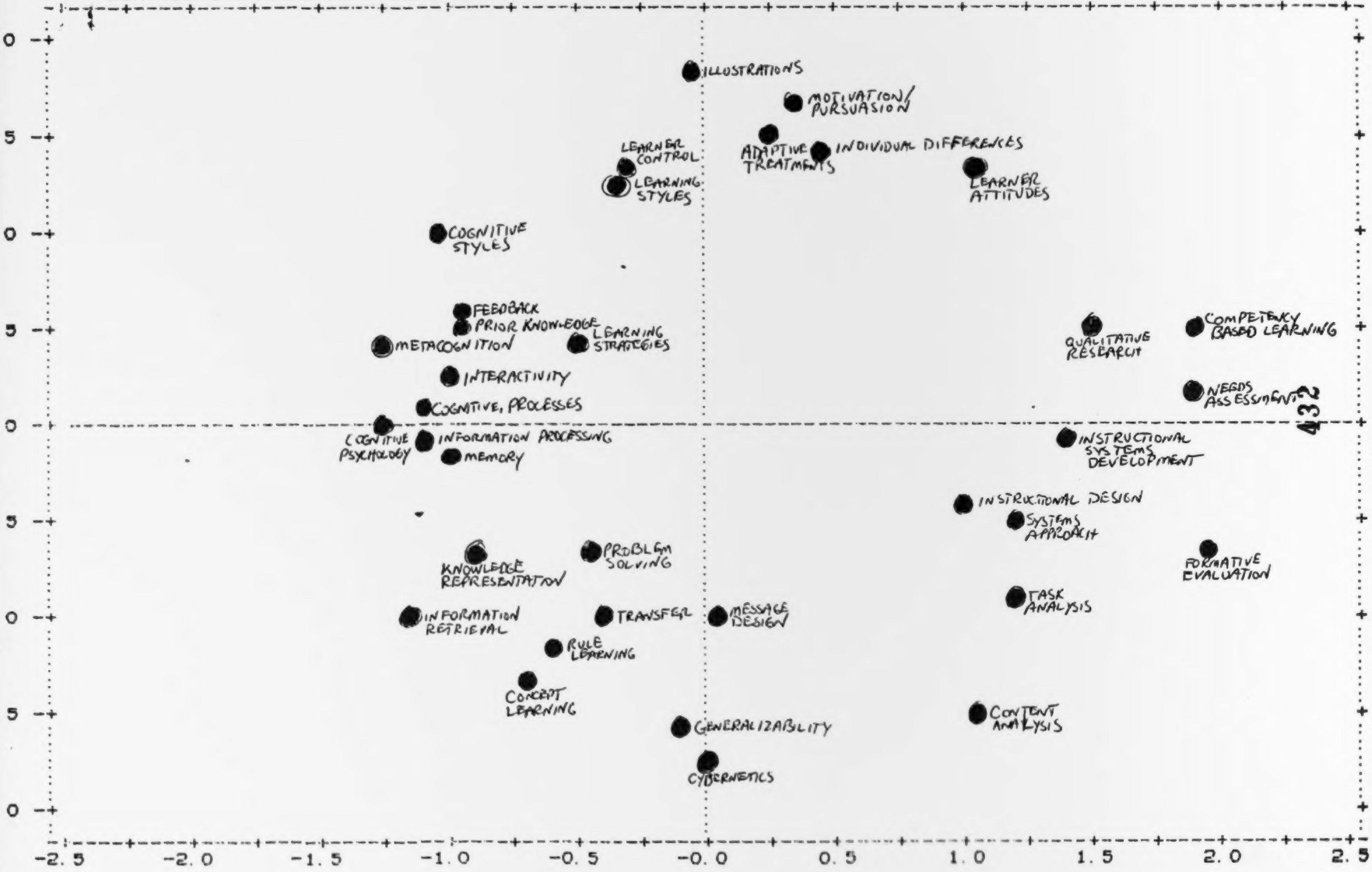
TWO DIMENTIONAL CONCEPT SCALING

DERIVED STIMULUS CONFIGURATION: DIMENSION 1 (HORIZONTAL) VS DIMENSION 2 (VERTICAL)



Title:

Prototype Development and Acquisition in an Interactive Video Concept Lesson

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PROTOTYPE DEVELOPMENT AND ACQUISITION IN AN INTERACTIVE VIDEO CONCEPT LESSON

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Introduction

Problem

Videodiscs are most commonly produced in the form of generic discs, ie. generic collections of still and motion video to support instruction in a field of study. The best instructional application of generic discs is as instance pools for concept lessons. Concept lessons depend upon a large, diverse collection of examples to provide enough of the matched, divergent example sets needed for concept teaching (Merrill & Tennyson, 1977). The thousands of images available on most generic discs (eg. the BioScience or National Gallery of Art videodiscs) make them ideal instance pools. What is needed in order to facilitate the use of generic discs as instance pools are good lesson templates for helping experienced and especially inexperienced designers to develop these concept lessons.

Concept Lesson Template

A useful template must be based upon good instructional design theory. Many models of concept formation are available (Millward, 1980). Probably the most popular among instructional designers is the Rule-Recall-Example-Practice presentation of concept definitions based upon exposition of the critical and variable attribute dimensions (Merrill & Tennyson, 1977). Problems often occur in applying this model to "real world" concepts, so Tennyson and Cocchiarella (1986) have provided an empirically based instructional design theory for concept instruction that is useful for developing a template. Their theory asserts that conceptual knowledge does not result from the memorization and application of defining criteria, but rather concepts are coded into memory as prototypes. Prototypes are abstractions of typical class members. Procedural knowledge of concepts is formed, as in expository instruction, by practice and feedback. In order to verify the prototype theory, Tennyson and others (1983) compared the formation of prototypes generated from seeing prototypic examples with classification from a list of defining attributes. In the prototype group, third graders compared each instance in the set with a prototype or "best example" of the concept, while the students in the attribute-list groups evaluated each instance for the presence of critical attributes. On immediate and delayed classification tests, the protoype groups outperformed the attribute groups.

Park (1984) corroborated these results when he compared an expository attribute isolation strategy (AIS) with a more generative example comparison strategy (ECS). The AIS group of twelfth graders used a list of attributes while classifying interrogatory instances. The ECS group compared a best example with each of the interrogatory instances while classifying them. In the ECS group, learners elaborated their own prototypes as decision criteria in classification tasks, while the AIS group used an externally-provided set of analytic attributes. The AIS learners classified more accurately during the instructional program, but their classification ability decreased significantly on the retention test. That the ECS group retained their ability longer indicated that their elaborations produced a more durable conceptual knowledge.

The AIS and ECS templates were compared in a videodisc-based concept lesson (Jonassen, 1986) which found no difference in concept acquisition or retention. The prototype treatment compared each new instance with a set of three best examples while the attribute identification treatment presented the list of critical attributes. In order to distinguish empirically between conceptual knowledge and procedural knowledge, it is neccessary to compare the effects of prototype development with and without practice.

Another instructional strategy that would likely improve the development of prototypes (conceptual knowledge) is an elebaoration learning strategy that forces learners to articulate their own prototypes. Jonassen (1985) promoted the inclusion of learning strategies in courseware to deepen the level of processing by learners. Previous prototype research (Park, 1984) compared prototype development with checkoff of an attribute list which was not a generative activity. What if learners generated their own attribute list for each concept? Such a strategy should produce deeper processing which should positively affect the development of conceptual knowledge.

Purpose of Study

The prototype model of concept acquisition is gaining general acceptance. What is not clear in that model is the role of conceptual knowledge and procedural knowledge in the prototype model. Tennyson et al (1981) showed that adding practice with new instances to expository instruction improved classification ability. In this study, we compare protoype instruction with prototype + interrogatory instances (practice). In order to assess the kinds of prototypes that learners develop, a third learning strategy treatment was added. In this study, we ask learners to use a combination of imagery and paraphrasing strategies to elaborate the prototype they develop.

METHOD

Participants

Thirty volunteer graduate students in education programs at two universities were randomly assigned to one of three treatment groups and completed the study.

Instructional Materials

Three treatments of an interactive video lesson on "Styles of Art" comprised this coordinate concept lesson, featuring the Rennaissance, Baroque, Impressionistic and Post-Impressionistic styles of art. Baroque and Renaissance and Impressionistic and Post-Impressionistic are close-in example/non-example sets, while each pair are far-out non-examples for the other (Merrill & Tennyson, 1977). Close-in non-examples are more difficult to discriminate from one another, resulting in a tendency to overgeneralize. The pretest, posttest, retention test, and instance pool required a rational set of 25 instances of each style of art. The set of examples came from the National Gallery of Art disc, which consists of a motion tour and art lesson and 3300 stills of 1400 works of art in the collection. The computer program is written for an Apple IIe driving a Pioneer LD-V2000 player through an Allen VMI interface card.

Treatments

All treatments included a 15-item pretest and posttest consisting of randomly sequenced sets of three examples of each style plus three distractors. Following the pretest, text was used to introduce the coordinate concept of styles of art. The treatments were presented next, followed by the posstest.

The prototype only presentation, providing only the concept knowledge development phase of concept acquisition, consisted of:
1) For each style of art, the name of the style was followed by three best examples (archetypical examples of that style). Participants were instructed to try to develop their own definition of the style.
2) A rational set of 16 was presented as examples. After each 10 second presentation, one best example of each style was presented. The participant decided which of the four best examples most closely resembled the example in terms of style. Knowledge of results was provided after each example.

The prototype + practice presentation, providing for the development of conceptual knowledge plus procedural knowledge, consisted of :
1) same as the previous treatment, plus
2) Ten additional practice items without prompting, followed by knowledge of results.

The prototype + elaboration + practice presentation, providing for development plus elaboration of conceptual knowledge plus procedural knowledge, consisted of:
1) the same treatment as in the prototype + practice, plus
2) After each set of best examples was presented, the screen was blanked and the participant was asked to close their eyes and form a mental image of that style of painting and then to type into the computer at least three characteristics of that style of painting. This imagery/paraphrasing strategy should improve conceptual development and improve practice and posttest classification accuracy.

Measurement

The dependent variables included posttest and retention test classification accuracy. The retention test was taken individually using the same configuration as in the treatment. The retention test, like the pretest and posttest, consisted of 15 items (3 of each style + 3 distractors).

Results and Discussion

The pretest scores for each of the groups (see Table 1 for group means) were not significantly different, $F(2)=2.06$, $p>.05$. Posttest scores, however, were significantly different, $F(2)=6.06$, $p<.01$. A Fisher's Least Significant Difference Test showed that the prototype only (control) group scores differed significantly from both of the other treatment groups. However, the prototype+practice and prototype+practice+elaboration groups were not significantly different. A bug in the computer program which drives the video player prevented the correlation of retention test data to the other scores as well as eliminating several student scores, so only the immediate posttest data for 30 subjects was available for analysis.

In order to factor prior knowledge of the subject matter, we conducted a repeated measures (group by pretest/posttest) analysis of variance. The analysis showed significant main effects for the repeated measure, $F(1)=62.36$, $p<.001$. It is obvious from the mean pretest and posttest scores that learning did take place. The main effect for group approached significance, $F(2)=2.63$, $p=.08$. The univariate analysis showed that the practice and practice+elaboration groups differed significantly from the control group on the posttest but did not differ between them. The change score (posttest-pretest) was higher for the practice+elaboration group ($M=5.5$) than for the practice group ($M=3.8$).

The prototype treatments obviously produced learning during the lesson. Practice has consistently been shown to improve concept learning (Tennyson et al, 1981). Virtually all of the mathemagenic literature supports that conclusion as well. Of greatest interest to this study was the effect of performing the elaboration strategy. This type of strategy forces learners into deeper processing. The results indicated a trend in favor of the elaboration strategy group. The loss of several subjects in the analysis probablistically affected those results. We will run additional subjects this winter and reanalyze the data.

The major unknown from this study is the effect of different treatments on retention scores. Previous research (Jonassen, 1986; Park, 1984) has shown that the prototype concept acquisition strategy is less susceptible to decay on retention tests. The elaboration strategy, if it in fact stimulates deeper processing, should produce even more resistant performance. Long term retention is normally positively affected by deeper processing. Additional subjects should clarify this and other remaining questions.

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Table 1

Group Means

	Prototype Only	Prototype + Practice	Prototype + Practice + Elaboration
Pretest	6.9 (2.3)	7.6 (1.9)	5.6 (2.6)
Posttest	8.7 (2.3)	11.4 (1.8)	11.1 (1.4)

Title:

Educational Connoisseurship and Educational Criticism: Pushing Beyond Information and Effectiveness

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EDUCATIONAL CONNOISSEURSHIP AND EDUCATIONAL CRITICISM: PUSHING BEYOND INFORMATION AND EFFECTIVENESS

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Fifth Annual Open Forum On
The Foundational Issues Of The Field

Association for Educational Communications and Technology
Annual Conference
New Orleans, Louisiana
January 14-19, 1988

> ...our language promotes a view, a way of looking at things, as well as a content to be observed. This language, I am arguing, derives from a set of images, of what schools should be, of how children should be taught, and of how the consequences of schooling should be identified. Language serves to reinforce and legitimize those images. Because differences between, say, terms such as instruction and teaching are subtle, we often use a new word without recognizing that the new word is capable of creating s new world. (Eisner, 1985, p.355)

The power of words (languaging) is probably the most overlooked, least understood, and ultimately most neglected phenomenon in the field of education. Words serve to produce a paradoxical situation: words can both "freeze" and "unfreeze" reality. It is my contention that the language of the dominant paradigm for educational thought tends to provide more of a "freezing" function.

This paper has a dual purpose. First, I present a brief description and critique of the dominant model of schooling. Secondly, I offer an alternative paradigm for analyzing school practice. The freezing of educational reality can be seen in the almost exclusive use of a technical-rational, management model of school practice, based on behavioral, positivistic, quasi-scientific language. This has become the dominant way of perceiving and talking about schooling. The current emphasis and obsession with students' scores on standardized tests has shifted attention from the art and craft of teaching to the "science and technology" of teaching. This has primarily taken the form of perceiving and talking about schooling from an effective schools/teaching model (Hunter, 1984; Lazotte & Bancroft, 1985). Another example of this model is found in management/systems thinking applied to the instructional process ; a reductionist view of the teaching/learning process which severely limits ways of looking at, talking about and living with students.(1)

An alternative model for analyzing school practice is offered by Elliott Eisner's (1985a) notion of educational connoisseurship and educational criticism. I will argue that Eisner's aesthetic paradigm can provide education a broader conceptual base from which to work in better understanding the complexities of the schooling process. This conceptual base givese educators a more diverse language system for understanding and interpreting what they see, and, vice versa, what they see and observe is not limited to forms of expression that use technical language.

The importance of examining the language base of educational paradigms/models cannot be over stressed. Educators use and/or invent words to serve as tools and their perceptions become controlled by these creations. Language which is intended to explain or describe reality, becomes reality. What can't be explained (or programmed into a computer) is too often ignored and ultimately dismissed. I am arguing that the way we talk about a phenomenon determines what we see before we look. The language of a field encourages human encounters to be a priori. If we are to pursue the reality of the teaching-learning act, educators must uncover the meanings of words blurred by custom and usage and be willing to examine the conceptual-base of their views of school practice.(2)

The Dominant Paradigm of Schooling

Wanting teachers to be effective and competent seems to be a reasonable expectation. However, designing the means of determining teaching effectiveness and teacher competency becomes complex. Traditionally, the major thrust in teaching effectiveness and teacher competency studies has been an emphasis on designing research studies that focus on the technical and political aspects of the teaching-learning experience. Basically, this research includes studies concerned with various instructional methodologies and pupil achievement (Fisher, Mariave, & Filby, 1979; Good, Biddle, & Brophy, 1975; Russell & Fea, 1963), teacher characteristics and teaching effectiveness (Coker, Medley, & Soar, 1980; Getzels & Jackson, 1963; Raskow, Airasion, & Madaue, 1978), and teacher behaviors as related to pupil achievement (Good, 1979; Rosenshine, 1976; Withall & Lewis, 1963).

In these paradigms for studying teaching effectiveness and teacher competency, little attention is focused on the nature of the research questions or why they were posed. To be satisfied with asking the right research question is not enough. Responsible educators must ask why the question was asked and why it was phrased in a particular manner. The scope and nature of research questions cannot be neglected. Scientific investigation is not value-neurtal.

A possible, and often overlooked, explanation causing the study of teaching effectiveness to follow technical lines of investigation may be the language of teaching. The power of language to influence or direct the study of teaching is supported by Soltis (1973), who suggests that a complex educational system develops a specialized voacbulary. Educational words have power--the power to direct the procedures and purposes of researchers. Typical words used in research on teaching effectiveness are behavior (student and teacher), effectiveness, personality, achievement, outcomes, interaction, characteristics, behavioral measurements, and performance. More recently, the literature is using such words as direct instruction, time on task, assignments, expectations, monitoring, pupil task involvement, seat work, and a whole host of terms reflecting technical and political value bases. The metaphorical bases of these words are industrial, military, and disease (medical). For example:

Industrial - classroom management, cost effectiveness,
efficiency, institutional planning,

programming, output measures, product, feedback, defective, input-process-output, quality control, time management.

Military - target population, information system, centralization of power, line and staff, scheduling, discipline, objectives, teaching strategies, maintain.

Disease - diagnosis, treatment, prescription, remediation, monitor, label, deviant, impaired, referral-procedure, special needs.

These metaphors encourage teaching-learning research to be viewed and investigated from a technical perspective. Researchers invented words to serve as tools and now they are controlled by these tools. Language which is intended to explain or describe reality too often becomes the reality. What cannot be explained with language is often ignored and ultimately dismissed. As mentioned earlier, words serve to produce a paradoxical situation, namely, the freezing and unfreezing of reality. This is due to the technical emphasis on defining terms, along with the emphasis on observable behavior to explain the human condition. If researchers are to pursue the roots of reality relative to teaching-learning, they must uncover the meaning of words blurred by custom and usage. Researchers of teaching effectiveness are affected by language and, more often than not, their research efforts reflect the posed meaning these words possess.

As expressed by Frymier (1972, p.13), there are languages of conditional relationships and relationships "without conditions": the first is a language of "control"; the second is a language of "love and growth." One has to wonder if teaching effectiveness has as its priority control or learning (love and growth). Roberts (1976, p.321) echoed this sentiment when she wrote, "It is impossible to practice the ideas of Skinner and Chomsky simultaneously."

Heubner (1966) discusses the dangers involved in the languaging activity. He refers to the language of the technical model in education as the prevailing focus during the past few years. Heubner, according to Macdonald (1977, p.15), "...opens the possibilities of political, aesthetic, and moral talk."

The language of the technical model applied to teaching effectiveness research has contributed to a simplistic, input/output understanding of educational experiences ("student-as-product" orientation). The technical model, along with the technical-rational language, suggests that the "right mix" of technique and content will significantly increase student performance. Teaching is viewed as a "science and technology" with identifiable skills lending themselves to short-term teaching goals that focus on a utilitarian perspective. Tabachnick, Popkowitz and Zeichner (1979-80) suggest that this leads to a managerial understanding of teaching.

The language of the technical model applied to teaching effectiveness suggests scientific accuracy and predictability, and the nature of this model has an interest in control (management and engineering). The historical roots of this orientation have been outlined by others (Apple, 1979; Giroux, 1980; Kliebard, 1975). Tabachnick et al. (1979-80, p.16), in their research on the student-teaching experience, observed student teachers engaged in the "routine and mechanistic teaching of precise and short-term skills and in management activities designed to keep the class quiet, orderly, and on task."

As the teaching profession has become an increasingly highly skilled technology with a primary emphasis on methods and outcomes, teachers have been rewarded for guiding their practice in ways amenable to this technology. As Macdonald suggests (1975), this notion implies that "teachers are potentially interchangeable," and leads to viewing productive activity as something learned and performed "mechanistically." Thus, any "good" teaching activity can be reproduced by any other teacher, and "...all productive teaching is measureable in terms of the criteria of the accountability in use" (pp.79-80).

Apple (1982) refers to this as a process of "deskilling-reskilling" teachers:

> As the procedures of technical control enter into the school in the guise of pre-designed curricular/teaching/evaluation 'systems,' teachers are being deskilled. Yet they are also being reskilled in a way that is quite consequential. ...while the deskilling involves the loss of craft, the ongoing atrophication of educational skills, the reskilling involves substitution of the skills with ideological visions of management. (p.256)

Tom (1977) contends that what is lacking in the managerial perspective is the acknowledgment of interpersonal or social relationships:

> ...these relationships cannot be reduced to a collection of techniques without debasing them and stripping them of their humanity. However, even if one rejects this humanistic concern, there is another fundamental problem. A technology must have definite ends toward which its activity is aimed. There is, of course, no long-term consensus on the aims of education. (p.78)

The lack of consensus on the aims of education within the technical model is not viewed as problematic because there are commonsense understandings of purpose within the model. The position here becomes one of value-neutrality, that is, teaching and learning as apolitical.

Giroux (1980) suggests that the political nature of education programs is seen in the language used to address everyday school practices. Stating that teacher education programs serve as socializing agencies enbodying "...rules and patterns for constructing and legitimizing categories regarding competence, achievement, and success," (p.8) he suggests that this, in turn, serves to define specific teacher roles

> ...through the language they use and the assumptions and research they consider essential to the teaching profession. The basic premises and rules that underlie such programs usually viewed as commonsence perceptions; they go unquestioned and often result in many problems in the teaching arena to be
> defined as basically technical areas.

In the same vein, Foshay (1980) proclaims the importance of language and its linkage to practice. He states:

> It is scarcely recognized the way we talk and think has a controlling effect. Behind our manifest language is a metaphor which carries latent meanings to events. Behind our action is also theory about the domain of action. (p.82)

Foshay's contention provides a clear picture of how theory and practice, talk and action are underlying sequences in everyday events and, quite possibly, research efforts. Haplin (9169) lends support when he states:

> But if the word is only as good as the idea behind it, we as educators should ask questions more frequently than we do, not just what this or that educational word means, but to what assumptions, values, theories, procedures, and strategies for teaching do these words commit us. (p.335)

Certain words used in teaching-learning research help us to "see" teaching effectiveness in a certain way, or ways of "seeing" teaching-learning have generated certain language systems. Casual priority does not seem particularly important here. What is important is the current language used connotes a simplistic technical view of teaching-learning.

Discussion

The non-neutrality of methods of inquiry has been argued by Habermas (1971) (3). Educators have argued the non-neutrality of education as a process (e.g. Apple, 1979; Aronowitz & Giroux, 1986; Dobson, Dobson, & Koetting, 1985; Eisner, 1985a & 1985b; Freire, 1970; etc.). However, the encouraged model of perception in teaching is one of value-neutrality in the form of observation. Certain behavioral characterictics of children are classified and labeled and teachers are trained to see these. This activity has resulted in the field of teacher education abounding with an "if-then" mentality, a reduction of the cause-effect model borrowed from natural science. If a child exhibits a certain behavior, then an appropriate treatment is prescribed. Apple (1979) argues that educators have borrowed a reconstructued logic of science and applied it to curriculum and pedagogical research and practice.

Patterns of thought or the usage of language schemes borrowed from the natural sciences simply do not fit summarily the social sciences. Exactness and precision are needed when dealing with things (natural sciences) for purposes of prediction and control. However, lattitude and flexibility are needed when dealing with humans for purposes of growth, emancipation, and understanding.

Apple (1975a) contends that "...two major problems in education historically have been our inability to deal with ambiguity, to see it as a positive characteristic, and our continual pursuit of naive and simplistic answers to complex human dilemms" (p.127). He continues by suggesting that phenomenologists seek to cast aside their previous perceptions of familiar objects and attempt to reconstruct them. The work of the phenomenologist is to see the phenomenon as it is rather than as it is suggested. The basic question becomes one of whether or not "familiar" educational constructs for viewing and speaking of children are adequate relative to the potential of children.

The consequences of an over-reliance on a technical-rational, scientific, management model for viewing the process of schooling have been numerous. So, too, the impact of the language used in this model. Eisner (1985a) identifies six consequences that he sees as most important. The first consequence is that a "scientific epistemology" dominates as the only legitimate means of educational inquiry. All other views are excluded (p.17). Secondly, this "scientific epistemology" in education is preoccupied with control. This has resulted in attempts at developing "teacher proof" curriculum materials and, diagnostic/prescriptive models of teaching (pp. 17-18). A third consequence is a preoccupation with "standardized outcomes," manifested in the current "testing movement" and teacher accountability/effectiveness (p.19). Fourth, students have no role/participation in developming educational programs because "the provision for such opportunities would make the system difficult to control, hard for educators to manage, and complex to evaluate" (p. 19). A fifth consequence is fragmenting the curriculum. This results in breaking up complex tasks into smaller, "almost microunits of behavior and in the process to render much of the curriculum meaningless to children" (p.20). A sixth consequence is that educational language has become an "emotionally eviscerated form of expression; any sense of the poetic or the passionate must be excised. Instead, the aspiration is to be value neutral and technical. It is better to talk about subjects than students, better to refer to treatment than to teaching, better to measure than to judge, better to deal with outputs than results" (p.20).

A way to address the limitations and consequences of the technical model identified by Eisner is to reconceptualize the schooling process. For example, Eisner (1985a) states that we need educational theory that "unapologetically recognizes the artistry of teaching" (p.22); that we need to develop "methods that will help us understand the kind of experience children have in school and not only the kind of behavior they display" (p.22). To gain an appreciation of educational experience will require methods of analysis and language forms that are different from the technical model. What the study of education needs

> ...is not a new orthodoxy but rather a variety of new assumptions and methods that will help us appreciate the richness of educational practice, that will be useful for revealing the subtleties of its consequences for all to see (Eisner, p.23).

Professionals must deal not only with what they see but with why they see what they see (Dobson, Dobson, & Koetting, 1985). The way educators look at (perceive), talk about (language), and live with (experience) children is an area worthy of critical analysis. The remainder of the paper explores one alternative framework for viewing schooling that adresses the consequences of Eisner, that allows for the complexities of schooling and that accepts the interplay of perception, language and values that are at work in looking at schooling.

An Alternative Perception of the Practice of Schooling

The inherent limitations of the technical model of schooling and its attended language system cannot be over come by "fine-tuning" the model. What is needed is an alternative conceptual base for looking at and talking about schooling. One such alternative model with an attended language system is Elliot W. Eisner's notion of educational connoisseurship and educational criticism. Eisner (1985a) states that "this form of educational inquiry, a species of educational evaluation, is qualitative in character and takes its lead from the work that critics have done in literature, theater, film, music, and the visual arts" (p.216).

Eisner (1985a) contends that there are two forms of qualitative inquiry in the arts. Artists use a qualitative form of inquiry when they become involved in making statements about reality through their art. The result is a "qualitative whole - a symphony, poem, painting, ballet - that has the capacity to evoke in the intelligent percipient a kind of experience that leads us to call the work art" (p.217). This is one form of qualitative inquiry. The second form is found "in the work of those who inquire into the work of artists, namely the art critics. The art critic finds himself or herself with the difficult task of rendering the essentially ineffable qualities constituting works of art into a language that will help others perceive the work more deeply" (p.217).

The critic's work is to be a "midwife to perception", i.e. he/she must use their knowledge (connoisseurship) to make public the qualities that make up the work of art so that others may see the work more comprehensively. The critic's task is not to pass judgment, but to lift " the veils that keep the eyes from seeing" (Eisner, 1985a, p.217). Thus criticism is defined as the "art of disclosure" (p.219)

Eisner identifies two important points about criticism. First criticism is an "empirical" endeavor, i.e. "the qualities the critic describes or renders must be capable of being located in the subject matter of the criticism. In this sense, the test of criticism is in its instrumental effects on the perception of works of art" (Eisner, 1985a, p.217). Thus criticism aims at understanding "qualities and their relationships."

The second point Eisner makes about criticism is that "anything can be its subject matter." Here, Eisner points out that criticism does not refer to "the negative appraisal of something but rather the illumination of something's qualities so that an appraisal of its value can be made" (1985a, p.218). The two points are crucial in understanding his use of criticism within the educational context, because although educators sometimes refer to teaching as an art, the language they commonly use in describing or understanding educational practice is not criticism, but the language of science (usually qualitative, empirical data).

There is a definite relationship of educational criticism to educational connoisseurship. Whether within the arts or in education, effective criticism is an act dependent on the powers of perception. It is this ability to see, "to perceive what is sbutle, complex, and important" that is the necessary condition for criticism. This act of "knowledgeable perception" is referred to as connoisseurship, i.e., to know "how to look, to see, and to appreciate." Connoisseurship is the art of appreciation. It is essential to criticism. Without connoisseurship, criticism "is likely to be superficial or empty" (Eisner, 1985a, p.219).

To be a connoisseur is to be involved in the art of appreciation. To be a critic is to be involved in the art of disclosure. Connoisseurship is a private act, consisting in the recognition and appreciation of the qualities of a particular, requiring neither public judgment nor public description of those qualities. Criticism, on the other hand, is "the art of disclosing the qualities of events or objects that connoisseurship perceives. Criticism is the public side of connoisseurship. One can be a connoisseur without the skills of criticism, but one cannot be a critic without the skills of connoisseurship" (Eisner, 1985a, p.223). Thus connoisseurship is essential to critisism, providing the "fundamental core of realization that gives criticism its material" (Eisner, 1985a, p. 220)

Experience in classrooms or educational settings is important to developing educational connoisseurship. Yet it is not a question of cumulative experience in classrooms. More important is the perception of, or "seeing" the experience, as opposed to "looking" or recognition of the experience for purposes of classification. Thus the connoisseur must become a "student of human behavior", seeing subtleties and focusing one's perception, attending to the "essence" of what is occuring. To attend to the essence of an event requires

> ...a set of ideas, theories, or models that enable one to distinguish the significant from the trivial and to place what one sees in an intelligible context. This process is not serial: we do not see and then assess significance; the very ideas that define educational virtue for us operate within the perceptual processes to locate among thousands of possibilities what we choose to see. The essence of perception is that it is selective; there is no value-free mode of seeing (Eisner, 1985a, pp.221-222).

In other words, our "perceptual processes" work within an "array of values and theoretical concepts that influence perception" (p.222). We use these theoretical constructs to better understand and interpret our world, and individuals will use different theories to explain/interpret the same reality.

It is here we begin to understand the demands placed on the educational connoisseur/critic, and the dynamic interplay between the two. It bears repeating that connoisseurship is a private act, criticism is a public act. One can be a connoisseur and not be a critic. But one cannot be a critic without being a connoisseur. To be a connoisseur of education requires "an understanding of different social sciences, different theories of education, and a grasp of the history of education" (Eisner, 1985a, p.222). The educational critic creates

> a rendering of a situation, event, or object that will provide pointers to those aspects of the situation, event, or object that are in some way significant. Now what counts as significant will depend on the theories, models, and values alluded to earlier. But it will also depend on the purposes of the critic.... What is rendered by someone working as an educational critic will depend on his or her purposes as well as the kinds of maps, models, and theories being used. (Eisner, 1985a, pp.223-224)

The notion of rendering is important here, and again, the interplay between connoisseurship and criticism is evident. The critic attempts to render, or translate into another language, to bring out the meaning of, to interpret qualities of something (an object, an event or experience, etc.), to disclose something that might not be evident. The critical importance of language comes into play here, and the distinction between discursive and non-discursive forms of expression is critical.

The technical-rational model discussed earlier in this paper severely limits the discourse about, and interpretation of, educational events. The limitation comes from the language system it uses, and the conceptualizations of schooling that become part of the language structure. This is a highly discursive form of communication, a language of classification, but not a language to use when particular "qualities of life" must be revealed (Eisner, 1985a, p.226).

Within Eisner's alternative paradigm, the mode of discourse is non-discursive, it is metaphorical. The critic must draw upon his/her knowledge/conceptual/experiential base and describe, interpret and evaluate what they experience. This is a language form that "presents to our consciousness what the feeling of those qualities is." This is the language of literature and poetry.

> What enables us to participate empathetically in the events, lives, and situations that the writer portrays is not mere factual description.... What

> gives literature its power is the way in which language has been formed by the writer. It is the "shape" of language as well as the perceptive recognition of the metaphorical, connotative, and symbolic character of particular words and phrases that makes written language literature (Eisner, 1985a, p.226).

The skills of the critic, as both communicator and connoisseur, are evident here. This is where the art and craft of the critic comes into play, translating knowledge from one form to another form. The form of communication used by the critic becomes the public expression through which the "life of feeling" and qualities of experience are made evident and shared. "The arts are not a second-class substitute for expression, they are one of the major means people throughout history have used both to conceptualize and express what has been inexpressible in discursive terms" (Eisner, 1985a, p.226)

There are three aspects, or dimensions, to educational criticism: descriptive, interpretive, and evaluative. The distinctions between the three are more analytical than factual, i.e. they each have a different focus and emphasis.

In the descriptive aspect of educational criticism, the critic attempts to "identify and characterize, portray, or render in language the relevant qualities of educational life." Eisner sees this aspect as making the greatest artistic demands on the critic, i.e., it is this aspect of criticism where the critic's "verbal magic must be most acute" (Eisner, 1985a, pp.230-231).

In the intrepretive aspect of educational criticism, the critic asks and answers the questions: "What does the situation mean to those involved? How does this classroom operate? What ideas, concepts, or theories can be used to explain its major features?" (Eisner, 1985a, p.233). This is where the critics "connoisseurship" is drawn upon to use the multiple theories, viewpoints, frameworks, models, conceptualizations, etc., to interpret the meaning of events in educational settings. The important point is, the critic draws upon his/her knowledge and intreprets classroom reality using differing theoretical models.

In the evaluative aspect of educational criticism, the critic makes an assessment of the educational importance or significance of the experience he/she has described and/or interpreted. Some educational criteria must be applied in order for the critic to make a judgment about the experience. This brings out the normative aspect of, and the value-ladenness of, educational experiences. For example, the function of educational criticism is to "improve the educational process." This can't be done "unless one has a conception of what counts in that process" (Eisner, 1985a, pp.235-238). The conception of "what counts" in that process, what constitutes a quality educational experience, is dependent upon the critic's knowledge-base (connoisseurship). History and philosophy of education are most important areas of study for the educational critic to make judgments regarding the value of educational experiences. History of education provides "the context necessary for purposes of comparisons", and philosophy of education provides "the theores from which grounded value judgments can be made." Hence, a broad undrstanding of the divergent theoretical aspects of education "makes it possible for the educational critic to appreciate what he or she rejects as well as what he or she accepts within educational practice" (Eisner, 1985a, p.238).

The educational connoisseur/educational critic understands the value-ladenness of his/her judgments. As is the case with any criticism, disagreement with any aspect (descriptive, interpretive, evaluative) of the criticism is open to debate. Eisner sees this as a strength of qualitative inquiry:

> For much too long, educational events have been assessed as though there were only one set of values to be assigned to such events.... Virtually every set of educational events, virtually every educational policy, virtually every mode of school organization or form of teaching has certain virtues and certain liabilities. The more that educational criticism can raise the level of discussion on these matters, the better. (Eisner, 1985a, p.237)

Thus multiple perspectives, diverse theoretical positions expand the dialogue of educators to alternative possibilties, which could help us better understand the complexities of the educational process. The notions of educational connoisseurship and criticism could help us "appreciate" the complexity and provide a broader base for making educational judgments (Eisner, 1985a, p.237).

Concluding Comment

Eisner's perspective on qualitative inquiry directly addresses the limitations of the technical-rational model discussed in the first part of this paper. Connoisseurship/criticism allows for a diversity of methods in epistemology, it allows for diversity of teaching methodology, it allows for alternative evaluation methods other than standardized testing, it allows for participation of students in the over-all educational process, it conceptualizes the whole picture of education as opposed to parts, and it provides a language system that can deal with ambiguity and complexity. In effect, Eisner has provided a language that can help educators "see" education differently, or help them to understand why they "see" education differently.

The conceptualizations of educational connoisseurship and criticism and its attended diverse language system provide educators with a language of possibility that unfreezes educational realities. At the same time, this method of qualitative inquiry provides us with a method for uncovering the meanings of our language that might be blurred by custom and usage, and a method for examining the conceptual-base of our views on school practice.

Because of the moral nature of schooling, what we do in education is worth "another look". Knowledge, percpetion, language, beliefs, practice: there is no separation.

Endnotes

1. The reductionist view I am referring to is related primarily to the limited language system used to talk about, and hence work within, a teaching/learning situation. The language system/world view is technical, efficient, "given", and unproblematic. See Dobson, Dobson, and Koetting (1985).

2. The following assumptions undergird my position in this paper:
    a. The way educators talk affects what they see (perceptions). This phenomenon also works in a reciprocal fashion. Causal priority does not seem particularly important.
    b. Perceptions and language are reflective of the philosophic posture (value system) of the person observing and talking.
    c. The interplay of these three variables (perception, language, and value system) influences the nature of the teaching-learning experiences (Communication).
    d. The language of a profession can a priori determine perceptions and consequently human experience.
    (Dobson, Dobson, & Koetting, 1985)

3. Habermas' "theory of knowledge" has three forms, or processes, of inquiry. Knowledge can be arrived at through (1) the empirical-analytic sciences, (2) the historical-hermeneutic sciences, and (3) the critically oriented sciences (critical theory). These forms or viewpoints of knowledge results in three categories of possible knowledge:

> Information that expands our power of technical control; interpretations that make possible the orientation of action within common traditions; and analyses that free consciousness from its dependence on hypostatized powers. These viewpoints originate in the interest structure of a species that is linked in its roots to definite means of social organization: work, language and power (Habermas, 1971, p.313).

These categories of possible knowledge thus establish the "scientific viewpoints" from which we can know reality in any way whatsoever: "orientation toward technical control, toward mutual understanding in the conduct of life, and toward emancipation from seemingly 'natural' constraints (Habermas, 1971, p.311). These modes of inquiry with constitutive interests delineate the way in which individuals generate knowledge.

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Title:

How Past Research on Learner Control Can Aid in the Design of Interactive Video Materials

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Association for Educational Communications
and Technology

National Conference - January, 1988

New Orleans, Louisiana

How Past Research on Learner Control Can Aid in the Design of Interactive Video Materials

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Introduction

Interactive video is the combination of a computer and a video source in a single instructional medium that provides the best characteristics of each. The computer provides intelligent branching and easily-changeable text, while the video source (tape or disc) provides true-life visuals with accompanying audio.

The following suggestions for the design of interactive video materials are synthesized from learner control studies in a number of areas. While these suggestions focus mainly on the use of learner control with interactive video, they also are generally applicable to instructional materials presented through computers without supplemental video.

Definition of Learner Control

Learner control can be described as the degree to which a learner can direct his or her own learning process. In theory, such control could include student choices at the curriculum level, the opportunity for a student to study a given unit or lesson as long as needed, or the ability of the student to select and sequence a variety of internal processing strategies (Merrill, 1980). However, this term most often describes the instructional choices made during a particular lesson. By definition, these choices can be made either by the instructional program (as originally defined by a designer) or by the learner during the presentation of the materials.

The use of learner and/or program control can also be described as the locus of instructional control, with the control of instruction being either external (program control) or internal (learner control). Hannafin (1984) used this terminology, describing external instructional control as shown in those situations where all learners follow a predetermined path established by the designer. Internal locus of instructional control is shown in lessons where individuals control the path, pace, and/or contingencies of instruction. Steinberg (1977) adds sequencing, instructional strategy, completion time, amount of practice, and level of difficulty to the variables that may be controlled either by the student or by the computer.

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(1) This paper is based on the dissertation research of both authors. Detailed results of this research will be presented orally at the conference. Readers are encouraged to also read Hannafin (1984) for a similar list of suggestions.

The specific variables under study in learner control research, therefore, typically include content, sequence, and pacing. Each of these may be included to some extent in each learner control study. Control of content is often studied by allowing some students to choose the amount of material they wish to learn, while control of sequence is usually researched by permitting some students to choose the order of their learning. Pacing, often neglected in some learner control studies, is now being investigated in some instances (e.g., Belland, Taylor, Canelos, Dwyer, & Baker, 1985) where pacing is controlled either by the learner or by the program.

Early Research with Learner Control

One of the earliest discussions concerning the ability of some students to control their own learning indicated that some adult learners tend to be able to direct their own learning when given control of their curriculum (Mager & Clark, 1963). A similar study (Fernald, Chiseri, & Lawson, 1975) showed that student pacing enhanced students' achievement and to some degree increased students' positive evaluations of a course.

Other early research in learner control (Judd, 1972; Judd, Bunderson, & Bessent, 1970; Lahey, Hurlock, & McCann, 1973) began to examine this instructional variable in greater detail. Generally, this group of studies showed that:

1. Learner control should perhaps only be used when the students already have some expertise in a content area.
2. Learners have mixed feelings over being given control over their learning (i.e., sometimes they prefer it, sometimes they do not).
3. Learners need training in the use of learner control to be able to use it effectively.

Merrill (1979) also reported studies on the use of learner control in computer based learning situations. While none of the data showed that the use of learner choice caused a drop in student learning, there was also no clear indication that the overall use of learner control consistently increased achievement, efficiency, or attitude toward the instruction.

Merrill (1979, 1980) also discussed the importance of students controlling their own cognitive processing of the information presented to them. In addition, Merrill stated that the challenge is not whether to use learner control at all, but how to help each student best use the learner control that is available.

Based on the above studies, some type of learner control (e.g., pacing or sequence) would appear to be appropriate for instructional materials presented through interactive video. This use may be particularly appropriate with interactive video as the instructional medium, since instructional control is needed both for computer text and video/audio material.

Training in how to use the available learner control options is also very important, especially with interactive video where the learning materials may be less structured and the system more complicated to use. Such training is particularly important with this new medium since the learner may be totally unfamiliar with this type of learning system.

Studies Supporting Learner Control

Supporting the idea that students would benefit from having a great deal of control over their own learning, Campanizzi (1978) showed achievement gains to be significantly greater under learner control than program control. In a similar manner, Newkirk (1973) showed that long-term retention (two weeks) was significantly greater and attitudes were slightly more favorable for those who were allowed to use learner control.

There also appears to be a strong, intuitive appeal for allowing students to choose the type of instruction they will receive (Carrier, 1984). In support of this intuitive appeal, Santogrossi and Roberts (1978) described how students without an externally imposed structure may be able to allocate more energy for new or difficult material and spend less time and effort on familiar content. They also stated that an instructor-selected pace, no matter what it may be, would be inappropriate or boring for a large proportion of the class.

Allowing students to skip over material they already know is also intuitively appealing in interactive video instruction, where materials are often designed to be learned in a less structured manner. While giving students this type of control may appear to be beneficial, it may in the long run reduce effectiveness by allowing other students, not familiar with the content, to also omit certain parts of the instruction.

Studies with Mixed Support for Learner Control

While the above research generally supports the use of learner control, another body of research (e.g., Balson, Manning, Ebner, & Brooks, 1984/85; Mayer, 1976; Reiser & Sullivan, 1977) has shown that such control is associated only with equivalent learning gains, rather than increased achievement. The results from this group of studies showed that:

1. Learner control is as effective (but not more effective) in terms of achievement scores for students using this control strategy.
2. Attitudinally, learner control is rated equal to (or better than) program control by students using these strategies.

In addition, students using learner control often chose to end an instructional sequence too soon when they were given control over the amount of information they were to see (control of content). One such study (Fisher, Blackwell, Garcia, & Greene, 1975) showed learner control to be associated with students working substantially fewer problems per day (although this group was rated higher in engagement by observers).

Fry (1972) also showed that subjects under a high degree of learner control learned the least, although they did form the most favorable attitudes toward the method of instruction. Gay (1986) showed similar results with the learner control groups overall showing lower or equal achievement scores than groups under program control.

These results somewhat reduce the justification for including some type of learner control in an instructional lesson. Based on this research, designers should limit to some degree the learner control available for students learning from interactive video materials. Such control should include only very limited control of content (choosing whether or not to study a particular lesson) and perhaps only partial control of the sequence and/or pacing.

Available learner control might specifically include the ability to choose the sequence of topics, the option to choose computer text or video materials, and the ability to control the overall pace of the presentation of the instruction. As described above, care should be taken when learners are allowed to choose whether or not to actually view certain materials (computer text or video sequences) since learner control of content may allow some students to omit important lesson modules.

Adaptive Control Strategies

One alternative to standard learner control has been the use of adaptive control strategies. Using a computer-based algorithm, this type of strategy adjusts the learning environment and prescribes instructional treatments within an individual lesson to meet individual student needs and characteristics (Tennyson & Rothen, 1979).

Although extremely complex to design, such systems have been used quite effectively in providing an alternative to strictly learner controlled or program controlled instruction. The results of studies in this area (Tennyson, Park, & Christensen, 1985; Ross & Rakow, 1981; Tennyson, Tennyson, & Rothen, 1980) have shown that:

1. Groups using adaptive control perform better than either program control or learner control groups on both immediate and delayed tests of achievement.
2. Groups using standard learner control generally finished in less time and performed less well in final achievement tests than those using adaptive control.
3. Groups using standard learner control showed an increasing deficit from the immediate test to the delayed test as compared to adaptive learner control (Ross & Rakow, 1981).

While much of the adaptive control research has been carried out with complex, instructional systems, interactive video designers can still learn some strategies from its implementation. The most important of these is obviously the importance of adapting the instruction to the needs of the individual learner currently using the system. While the adaptation used in most interactive video systems cannot be nearly as comprehensive as that used in the research described above, it can still include appropriate pretests, embedded questions, and other attempts at understanding the needs of the learner.

Such adaptation is particularly important with interactive video where the complexity of the system may overwhelm some learners. Decisions concerning the appropriate use of computer text, branching, and video playback at appropriate times in a lesson are extremely important, especially when numerous options are available in the learning system.

Learner Control with Advisement

Another type of learner control research can be described as learner control with advisement, a situation where the learner is able to make some decisions as to content, sequence, etc., while the program makes suggestions for some of those choices. Such advisement may be necessary since typical learner control strategies may fail to provide students with the necessary cognitive information about their learning progress by which they can make meaningful decisions (Tennyson & Rothen, 1979).

Subjects using this advisement control strategy have been compared to groups having complete control or adaptive control of an instructional program in a number of different studies (Hannafin, Garhart, Rieber, & Phillips, 1985; Tennyson, 1980; Tennyson, 1981; Johansen & Tennyson, 1983). The results of these studies showed that groups receiving advisement information in general:

1. had higher post-test means,
2. had more students reach mastery,
3. had longer time on task,
4. needed less instructional time, and
5. needed fewer instructional instances.

In a similar study, Laurillard (1984) found that students do make use of instructional suggestions and like being given advice on what to do next in terms of sequence and strategy. Goetzfried and Hannafin (1985) also found that learning using a learner controlled advisement strategy was effective, reporting comparable learning results among an adaptive strategy, an advisement strategy, and a typical linear, program control strategy, although linear control was more efficient in terms of time.

The above results may also be applied to the design of effective interactive video instruction. Unlike the difficulty of applying adaptive control strategies, advisement can be easily applied to interactive video. Such advisement could include any or all of the following:

1. Suggestions for choosing a particular instructional sequence.
2. Suggestions for viewing a videotape/ videodisc passage for more information.
3. Giving extra information concerning why a particular choice should be made.

Effects of Learner Characteristics

The use of learner control has also been shown to be affected by certain student characteristics. For example, while Fry (1972) showed that learner control overall was a detriment to learning, its use actually increased learning when the students were of high aptitude and high inquiry. In a similar manner, Gay (1986) demonstrated that students using learner control were much more efficient in the use of their time when they had a prior conceptual understanding of the material.

Ross and Rakow (1981) also supported this type of interactive effect, showing that high entrance ability students performed equally well under both program and learner control conditions. In a similar way, Allen and Merrill (1985) discussed the differential effectiveness of learner control in their description of an "expert learner," described as someone who can select and apply appropriate learning strategies without help. Studies such as these suggest that while learner control overall may not be an effective or efficient learning strategy for all students, it may be worthwhile for those learners with higher aptitude or previous knowledge of the instructional content.

This research suggests that learner control with interactive video can be used most effectively with higher ability students or with students who already have some knowledge in the content area to be taught. If instruction is being designed for learners other than these groups, there should be limits placed on the amount of available learner control.

Research with Learner Control and Interactive Video

Specific studies looking at the use of learner control with interactive video have been very small in number. While this lack of studies is probably due to the lack of overall research studies with this new medium, there have been several studies of importance in this area.

One of the first studies learner control and interactive video (Laurillard, 1984) reported a small field trial of this new technology at the Open University in England. Using interactive videotape, this study showed that:

1. Students make sequencing choices that are often different from the expected sequence.
2. Students like advice on what sequence or strategy to use at a certain point.
3. Students do make use of this advice when offered.

Laurillard also stated that student control of sequence in free learning situations is important since a student's choice of route is likely to be more meaningful than the alternate routes not chosen by the student during the program.

Hannafin, et. al. (1985) also discussed the use of learner control in interactive video instruction. While stating that it is not advisable, in general, to allow learner control unless additional prompting is provided, these authors also stated that there is evidence to suggest that an imposed lesson structure has the potential for conflict with a learner's internal schema.

Finally, Gay (1986) reported research which showed an interactive effect between prior familiarity with a topic and the use of learner control in an interactive video learning situation. While overall posttest scores were higher with subjects under program control, equivalent scores were reported between program and learner control for those students with a high prior conceptual understanding of the material. As described above, Gay also demonstrated that students with a prior conceptual understanding of the material were much more efficient in the use of their time when using learner control. According to the author, it appeared that prior conceptual understanding may have acted as an advance organizer, making the presentation of well-structured materials (program control) considerably less important.

Findings from this research are similar to the results already described in the preceding sections. These findings include the importance of providing students with advice concerning learner control options, the possible negative effects from an imposed lesson structure, and the importance of previous knowledge when using learner control.

Conclusion

While most of the above research concerns the use of computers to present instructional materials, much can also be gained from this research concerning the effective design of interactive video materials. Suggestions for this design are summarized below:

1. Some type of learner control may be appropriate in many different interactive video learning situations.
2. Training in how to use learner control options is extremely important.
3. Learner control of content is often not appropriate since some students may skip important material or quit the lesson too soon.
4. The adaptation of interactive video materials for each learner, although potentially difficult, is very important.
5. Advising a student during instruction as to sequence, etc. should help increase retention.
6. Learner control may be most effective with higher ability learners or those with some prior knowledge of the content.

While the above suggestions certainly do not guarantee the effective design of interactive video materials that incorporate some type of learner control, they should aid the instructional designer in the incorporation of various learner control options. The appropriate use of these suggestions should also increase the effectiveness of the materials that make use of these options.

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Title:

Cognitive Style and Subliminal Instruction

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Cognitive Style and Subliminal Instruction

a
Paper Presented
at the Meeting of the

Association for Educational Communications and Technology
New Orleans, LA

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January, 1988

The inclusion of subliminal messages within the educational films or videotape might be a useful but controversial technique. Subliminal perception is defined as a visual stimulus which occurs below the level of conscious awareness and could effect an individual's behavior. Moore (1982) suggested that possible uses of subliminal messages in instruction might include: directing student attention, reiterating certain concepts, promoting affective goals or supplanting perceptions of visual elements or actually teaching unrelated concepts. Amid the controversy in the late fifties over subliminal perception used in advertising, numerous research studies have failed to indicate consistent results.

In some earlier studies which used television or film, it was attempted to teach one idea or task while viewing an unrelated program. These approaches did not prove successful, as students did not perform better from subliminal instruction unrelated to the content in the program (DeChenne, 1976; and Taris, 1970). Moore and Moore (1984) however, found a significant difference in recall between field independents and field dependents when viewing subliminal television captions which supplemented visible captions and thus, may be an effective device for improving achievement attributable to cognitive style. This potential of subliminal activity to improve instruction as shown in the Moore and Moore (1984) study suggests a possible interaction between cognitive style and subliminal information. This result gave rise to the possibility of the current study -- testing if cogntive style (individual differences of field dependence-independence) would interact with a subliminal task taught within a film (videotape) of unrelated context. To test this possibility a partial replication of the earlier study by DeChenne (1975) was conducted.

Ausburn and Ausburn (1978) urged continued study into the relationship between properties of media and the characteristics of individual learners. Witkin and his associates have conducted most of the research and have provided much of the information concerning the cognitive style of field dependence and field independence. Much of their work is summarized in the Review of Educational Research, Witkin, et al. (1977). People classified as field independent tend to be able to give structure to unstructured material and can separate parts from its whole. Field dependents need structure and tend to view objects and scenes in their entirety. Compared to field independents, field dependents have a greater need for and are more dependent on external sources of structure and organization. Information recall from visuals for field dependents is facilitated if major cues are irrelevant or not noticeable. Field independents tend to be able to take information from both irrelevant and relevant cues. Field dependents tend not to add structure to visuals and accept visuals as presented (Witkin et al., 1977).

Differences in learning may result from an interaction between cognitive style (field dependent, field independent) and the teaching subliminally a task unrelated film or tape being shown. It appears that the ability to perceive subliminal messages varies and cognitive style could be a factor. Moore (1982) states:

> How people perceive a televised image that contains a subliminal message may be partially determined or influenced by the process they use to analyze and decode the visual field... and as such may be related to cognitive style (p. 27).

Because field independents are more capable of consciously discerning parts of a visual scene and field dependents have more difficulty with a similar task it is hypothesized that field independents would be able to discern subliminal messages better than field dependents. Although, subliminal messages are not consciously perceived. The repeated nature of the presentation (14 times) and the formal structure of organizing the information (i.e., the seven parts of the puzzle presented in the same order) might increase the importance of context cues and make them more relevant for the field dependent person. Thus field dependents who were shown the subliminal treatment might in fact do better in completing the task than those field dependents who were not given the subliminal message. The purpose of this study was then to test these hypotheses of students' ability to learn a subliminal task while viewing a non-related film.

DeChenne (1976) attempted to teach problem-solving psychomotor skill by subliminally showing the pieces of a puzzle being assembled. On a videotape, the seven consecutive steps for assembling the puzzle were repeatedly superimposed on a university public relations film. Elementary, high school and college age students comprised the sample groups. Following the tape, the participants took a timed test to assemble the puzzle. Only a few participants in any group were able to assemble the puzzle correctly, but there was a tendency for the subliminal treatment groups to assemble correctly the puzzle more frequently than the associated control groups. This tendency was not statistically reliable. However, no measures of individual differences were taken into account. In this study using an older audience of all college students, the above study was partially replicated using cognitive style (field independence, field dependence) as the independent variable to test the hypothesis of the interaction of cognitive style and subliminal instruction.

Subjects

The subjects for this experiment were 132 undergraduate college students (92 female, 40 male) enrolled in professional education courses. These subjects were classified as field dependent, neutral or as field independent by means of the Group Embedded Figures Test (GEFT) (Consulting Psychologists Press, 1977). Because the test manual sets no guidelines for grouping, the subjects were arbitrarily assigned into the above categories in approximately thirds based upon their scores (0-18). Subjects with scores of 15 and higher were classified as field independent (N=47), those subjects with scores ranging from 11-14 as neutrals (N=45) and those with scores of 10 and under were classified as field dependent (N=40).

Procedures

The task chosen by DeChenne (1976) to be taught subliminally was the assembly in order the pieces of a tangram. A tangram consists of seven geometric figures when correctly assembled, for a square. The seven parts of the tangram are illustrated in Figure 1.

For the production of the slides, the seven geometric parts of a tangram were cut out of posterboard. The seven geometric figures were assembled and photocopied on a copy stand to form a square. As each figure was placed on the copy stand, a slide was taken. The completed slide series consisted of the seven slides also illustrated in Figure 1.

The following criteria were used in selecting the film used in this experiment.

1. The film was approximately 15 minutes in length.

2. The content of the film did not contain academic subject matter.

3. The content of the film was not related to the task taught subliminally.

A promotional film was entitled "Tech Territory" produced by the Informational Services Film Unit at Virginia Tech was selected.

Two video tapes were produced for use in this study. One video tape contained subliminal the stimuli and the other contained no subliminal stimuli. For the production of the video tape containing subliminal stimuli, the 2 inch by 2 inch slides showing the step-by-step procedures involved in assembling the seven geometric figures of a tangram into a square were presented by a Schneider Synchro-Compur shutter with a setting of 1/200 of a second. A video tape recorder recorded the simultaneous projection of the film through the film chain and the superimpostion of the projected slides.

The slides were presented at five second intervals until the entire slide series had been presented. The entire slide series was presented 14 times during the showing of the video tape.

For the production of the video tape containing no subliminal stimuli, the film was projected through the film chain and recorded by a video tape recorder. The subjects viewed either the film with the subliminal stimuli or the film without the stimuli by random selection. They viewed the presentation on the same 25 inch television monitor in groups of eight or less. At the completion of the video tape, each subject was given an envelope containing the seven pieces of a tangram and given 10 minutes to assemble the pieces into a square. Upon time being called the number of pieces assembled correctly was noted. The total presentation was approximately 25 minutes including instruction and time to assemble the tangram.

The dependent variable used in this study was to be the number of pieces, zero to seven, assembled correctly. Only pieces assembled in the manner described by the subliminal slides were to be counted. The independent variable was field-dependence, neutral or field independence.

Results

A two way analysis of variance was the statistical design used in this study. The summary table of the analysis of variance based upon the means in Table 1 is presented in Table 2. The F ratio dealing with field dependency (F(2,126) = .70, p = .5007) was not significant. Neither was the F ratio dealing with treatment (subliminal or non-subliminal) (F(1,126) = .02, p = .8822) nor was the F ratio dealing with interaction between dependency and treatment (F(2,126) = .74, p = .4804). As shown in the Table of Means, the mean scores for all groups were quite small considering the possible 0-7 as the criterion score. None of the main effects nor the interaction between cognitive style and treatment were significant.

Discussion

In an effort to see if cognitive style and the attempt to teach a task non-related to a videotaped presentation, it is clear that the attempt do not work. The results were similar to what DeChenne (1976) originally reported, subjects in this study were not able to be taught a task subliminally no matter what cognitive style. These findings are also in accordance with

Taris (1970) who was unable to teach a science concept subliminally. Skinner (1969), however, was able to increase vocabularies of ninth graders via a subliminal approach. DeChenne (1976) in his original study suggested that the size of screen, the resolution of the color video tape and the placement of the subliminal stimuli over moving objects on the screen may have limited the subjects' ability to perceive the stimuli. Moore (1982) in reviewing DeChenne's experiment also suggested that if the subliminal treatment had stressed the final, assembled pattern rather than arbitrarily defined sequence of placement, there might have been a larger number of correctly assembled parts.* This author, however, feels that there are other possibilities. First, the task may have been too difficult and the amount of subliminal and the amount of subliminal stimulus too small. In setting up the design of the study it had been decided to use a subliminal tasks unrelated to the content of the film presentation. The subliminal instruction was to stand alone and not reinforced by the film's content to avoid a confounding factor of sources of information. However, because of this fact that subjects were concentrating on the content of the video tape itself may have caused the communication channels to become overloaded and/or confused. This, of course, had assumed that a subliminal approach would or could teach a concept. It is obvious at least in this experiment and in that of the earlier DeChenne experiment, non-related subliminal instructional task within a film (videotape) was not taught no matter what cognitive style. Although in this experiment the means were higher (not significantly) for the subliminal treatment for both field independents and field dependents. This was also true in DeChenne's earlier experiment. The mean of criterion scores 0-7 indicated the average was just above 1.0, which indicates that an individual subjects were able to get only a small part of the puzzle correct. It was hypothesized that field independent individuals would by their nature, be able recognize and thus disembed consciously or unconsciously the subliminal stimuli and to use that information to assemble the puzzle than field dependents. The field dependents which had the subliminal treatment did not do significantly better than those not receiving the subliminal treatment as hypothesized. However, there may be a possibility that subjects could be taught this skill of if alerted to the fact of subliminal presence and the task at hand.

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*Note: In this study both the order of pieces and the final pattern were reviewed with no difference in the final result.

The author expresses gratitude to Ms. Janice McBee for assistance in the statistical analysis.

This paper is based upon the following article: Moore, D. M. (1985). Cognitive Style and a Subliminally Taught Task. Media and Adult Education, 7 (1), 47-53.

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Table 1

Correct Answer Means by Cognitive Style and Treatment

	N	Mean	Overall Dependency
Field Independent	47		1.54
Non-subliminal	28	1.29	
Subliminal	19	1.79	
Neutral	45		1.14
Non-subliminal	22	1.36	
Subliminal	23	0.91	
Field Dependent	40		1.05
Non-subliminal	19	1.00	
Subliminal	21	1.09	

Table 2

Analysis of Variance

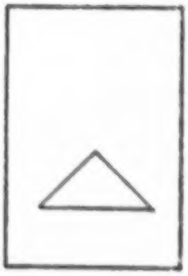
	df	ss	MS	F
Field Dependency	2	4.875		0.70
Treatment	1	0.077		0.02
Dependency x Treatment	2	5.169		0.74
Model	5	10.120	2.024	
Error	126	441.599	3.505	
Total	131	451.720		

*p > .05

**p > .01

***p > .001

ws118.8



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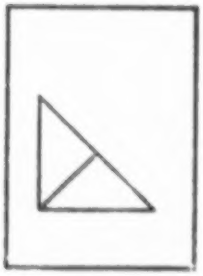

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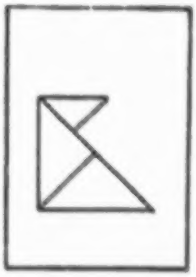

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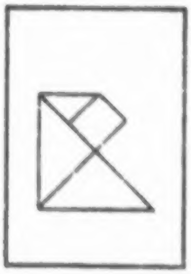

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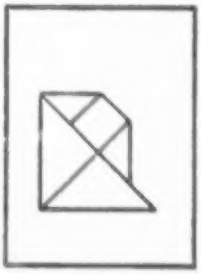

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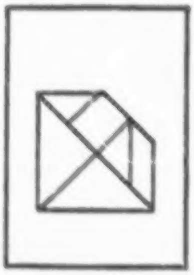

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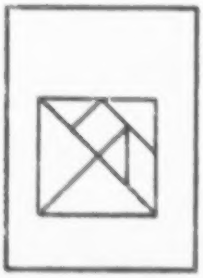

SLIDE NO. 7

Title:

Screen Density and Text Density: Getting More Out of Less with CBI

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Research in Computer-Based Instruction

Screen Density and Text Density: Getting More Out of Less with CBI

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Presented at the 1988 Annual Meeting of the
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Although the computer screen and printed page are both used to present text, there are unique qualities and constraints the designer must consider when working with each (Hartley, 1987). A review of commercial software packages will reveal that the computer screen is frequently treated as an electronic representation of the printed page (Bork, 1987; Burke, 1981; Keller, 1987) with the designer attempting to follow the same rules and heuristics that have guided both the design and layout of printed information. Comparisons between microtext and print on difficulty and reading speed have yielded mixed results (Barbe & Milone, 1984; Fish & Feldmann, 1987; Hansen, Doring, & Whitlock, 1978; Heppner, Anderson, Farstrup, & Weiderman, 1985; Morrison, Ross, & O'Dell, in press; Muter, Latremouille, & Treurniet, 1982), but an apparent limitation of many of these studies is the failure to design the text displays in a manner that fits each medium. Fish and Feldman (1987) for example, made their print pages duplications of their computer-based instruction (CBI) screens, a procedure that adds rigor to the comparison, but little realism.

Constraints imposed by the computer display include (a) a display limited to one page at a time, (b) restricted backward paging and review, (c) page layouts in either 40 or 80 columns by 24 lines, (d) limited cues as to lesson length, and (e) relatively poor resolution. Advantages of the computer include the ability to create response-sensitive, highly flexible, and dynamic displays without cost constraints on the use of color or number of pages. Recent suggestions for the design of computer displays emphasize minimizing the amount of text presented by using wide margins, double-spacing, and fade-out of unneeded information (Allessi & Trollip, 1985; Bork, 1987; Grabinger, 1983). Implementation of these guidelines, however, has the disadvantage of requiring an increased number of frames to display the same amount of information. It seems both theoretically and practically important to explore ways of using screen display areas efficiently.

The research described in this paper was designed to identify alternative methods for displaying computer text. Its specific focus was on the level of "richness" or detail presented in each display, a variable that we have labeled "density level." In related research with print material, Reder and Anderson (1980; 1982) compared complete chapters from college textbooks to summaries of the main points on both direct and indirect learning. The summaries were found comparable or superior in 10 studies reported. They concluded that the summaries may help the learner focus on the main ideas without the distraction of additional elaborations.

Similar to Reder and Anderson's (1980; 1982) construct, the present text density variable includes such attributes as length of material (number of words), redundancy of ideas, and depth of conceptual support for the main ideas. Reading researchers have referred to such text attributes as "microstructure" (Davidson & Kantor, 1982). Following Reder and Anderson's, procedure we generated low-density material from conventional text by: (a) defining a set of rules for shortening the text, (b) having two individuals apply the rules to the rewriting of the text, and (c) requiring those individuals to arrive at a consensus on the content of the summary. The specific guidelines for shortening the text were as follows:

1. Reduce the sentences to their main ideas.
    a. Remove any unnecessary modifiers, articles or phrases.
    b. Split complex sentences into single phrases.
2. Use an outline form instead of a paragraph form where appropriate.
3. Delete sentences that summarize or amplify without presenting new information.
4. Present information in "frames" containing limited amounts of new information, as in programmed instruction.

Applying these rules to a textbook unit of instruction consisting 2,123 words on 18 pages yielded a final low-density version consisting of 1,189 words, a 56% savings on 15 pages, a 17% savings. In designing the final lessons, a critical decision was whether to match print pages to CBI screens in order to maximize their similarities for analyzing media differences. We decided instead to sacrifice internal validity to create highly realistic page and screen designs for evaluating text density effects (with high external validity) within each medium. Accordingly, print pages and computer frames were designed using what were subjectively determined to be the most appropriate layouts for the content. Final versions of the CBI lessons resulted in 49 frames in the low-density lesson and 66 frames in the high-density lesson. Figure 1 shows a sample frame from the two density levels. Both frames present the same main ideas, however, the high-density version includes additional elaborations and supporting context.

Insert Figure 1 about here

Our main research interest was testing the effectiveness of the low-density materials just described. Low-density narrative was hypothesized to promote better learning and more favorable attitudes on CBI lessons by reducing reading and cognitive processing demands of the screen displays. A second area of interest was the effect of learner preferences for the two density levels in the print and CBI modes. Prior research on learner control (LC) has shown positive results in some studies (Judd, Bunderson, & Bessent, 1970), while more recent findings have been negative (Carrier, Davidson, & Williams, 1985; Fisher, Blackwell, Garcia, & Greene, 1975; Ross & Rakow, 1981; Tennyson, 1980). In contrast to typical uses of learner control for selecting the quantity or difficulty of materials, the text density variable represents a "contextual" lesson property that would seem primarily oriented in subject-matter to accommodating differences in reading ability and learning styles (rather than aptitudes or abilities). Thus, it appeared worthwhile to explore as a learner control option. To investigate these questions, we conducted an initial study (Morrison et al, in press), which is summarized below.

Study I

Subjects were 48 undergraduate teacher education majors who were randomly assigned to six treatment groups. The treatment groups were arranged by crossing two presentation modes (computer vs. print) by three text density conditions (high, low, and learner control). Dependent variables were different types of learning achievement (knowledge, calculation, and transfer), lesson completion time, and learning efficiency. During a regular class meeting, subjects completed a brief survey to asses attitudes towards mathematics and CBI. They then attended small-group sessions in which they completed the instructional unit followed by an attitude survey and an achievement posttest.

Results indicated the high-density and low-density materials were selected almost equally by the combined CBI- and print-LC groups ($\underline{n}$=16). The print group selected low-density text an average of 3.75 (out of 5) times while the CBI group selected high-density an average of 3.75 times, the exact opposite pattern. Achievement results indicated the print group performed significantly better on the knowledge subtest (definitions) and on the calculation subtest. No significant density level effects occurred. Print subjects ($\underline{M}$=18.0 min.) took significantly less time to complete the lesson than did CBI subjects ($\underline{M}$=32.3 min.), and the low-density group ($\underline{M}$=20.8 min.) took less time than the high-density group ($\underline{M}$=27.8 min.). With regard to attitudes, high-density print subjects perceived the lesson as moving faster than did CBI subjects. Also, low-density CBI subjects rated the materials higher in sufficiency than did the print subjects.

These results were consistent with those obtained for college textbooks (Reder and Anderson, 1980; 1982) by indicating that low-density materials were just as effective for learning as high-density materials. Also of interest was the LC density selection pattern showing the print group to prefer low-density material and the CBI group to prefer high-density material. This pattern, along with the very slow pacing by the CBI group, might indicate a lack of confidence by the latter in using the computer to learn. The results of the attitude survey indicated differences in the way the media and density levels were perceived. Print subjects judged the high-density material as moving faster than did the CBI subjects. This perception may have been due, in part, to the difference in the number of words viewed at a time (e.g., page density) in the two different modes. That is, with the realistic display formats used, CBI subjects were required to view almost four times as many "pages" as were print subjects. Another significant difference was that the CBI subjects rated low-density material as more sufficient than did print subjects. Thus, while high- and low-density materials had comparable influences on learning, "less" was perceived as "more" in the CBI mode.

A major limitation of this study was the low $\underline{n}$ (only 8 per cell) which obviously reduced the sensitivity of the various hypothesis tests. Other limitations were the lack of a pretest for evaluating the initial knowledge of the groups and a delayed posttest to assess long-term achievement. The results also raise some interesting questions regarding the effectiveness of the LC strategy. Overall, and in contrast to the pattern in other studies (Hannafin, 1984), low-performers did not seem to favor the "low-support" option (i.e., low-density) text over higher support. High-density text was actually the predominant choice in the CBI condition in which achievement scores were lowest. Further, although no significant differences were found, learner-control was directionally highest for print subjects and second highest (below low-density) for CBI subjects on all achievement subtests. These results suggested a further examination of the learner-control strategy using a larger n.

Study II

Study II (Ross, Morrison, O'Dell, 1987) extended Study I in several ways. First, comparisons between density and presentation modes were replicated with larger samples, an immediate achievement posttest, and a delayed achievement posttest. Second, the examination of learner control was extended to include selections of both text density ("partial-LC") and presentation mode ("full-LC"). Specifically, as in Study I the partial-LC treatment allowed subjects to select either a high-density or a low-density presentation in the print and CBI modes. Subjects in full-LC treatment, however, were allowed to first select either the print or CBI mode, and to then select a high-density or low-density presentation within the selected mode. A third major interest was examining the relationship of individual difference variables of reading ability and prior achievement to learning from "conventional" (high-density) computer text displays.

Subjects were 221 undergraduate teacher education students. They were randomly assigned to the seven treatment groups arranged according to a 2(presentation mode: computer or print) x 3(density: high, low, or LC) factorial design with one outside condition (full-LC). Seventy-five subjects from the total pool were preassigned to the high-density CBI treatment to support the supplemental analysis of individual differences and learning in that treatment. Prior to the instructional session, subjects completed a preattitude survey, pretest on the instructional unit, and the Nelson-Denny Reading Test (Brown, 1976). During the instructional session, they completed the unit on central tendency used in Study I, the attitude survey, and the achievement posttest. A delayed posttest was administered approximately two weeks later.

Comparisons of the full- vs. partial-LC conditions found no significant differences due to LC-strategies on achievement, attitudes, density selections. There was, however, a significant interaction on completion time between LC-strategy and presentation medium. Under CBI, the full-LC group (M=18.9 min.) took significantly less time than the partial-LC group (M=29.0 min.), indicating that those who selected CBI completed the lesson more quickly than those who were prescribed CBI. In the full-LC treatment, subjects' choice of mode was almost equally divided between print (n=11) and CBI (n=13). A discriminant analysis identified reading rate to be a significant discriminator between those who selected CBI and those who selected print. Subjects selecting CBI had a higher reading rate than those who selected print. Analysis of the number of low-density selections made by all LC subjects showed a general tendency for subjects to select low-density text (on about 70 percent of the trials) regardless of presentation mode. In multiple regression analysis, reading rate again was found to be the only significant predictor. As reading skills decreased, the tendency to select low-density material also decreased.

Significant density effects on achievement occurred on the calculation, transfer, and delayed retention measures. In all cases, the LC group had the highest mean of the three treatments with a significant advantage indicated on the latter two measures. The presentation mode variable in contrast, had generally small effects, only one of one of which was significant: CBI surpassed print on the delayed posttest.

Analysis of completion times indicated that the CBI group ($\underline{M}$=25.8 min.) took significantly more time than the print group ($\underline{M}$=21.5 min.), and the high-density group ($\underline{M}$=26.5 min) took significantly more time than the low-density group ($\underline{M}$=21.0 min). When the means for the CBI mode were adjusted to account for delays due to keypressing and screen construction, the presentation mode effect was no longer significant; however, the significant density condition was maintained.

The relationship between learner characteristics and learning from high-density CBI was analyzed using a stepwise multiple regression. When immediate posttest scores were treated as the criterion, reading comprehension was the first predictor entered in the equation with pretest score entered on the second step. No other predictors were entered. In contrast, reading scores were not selected as predictors in any other treatment group equations, while pretest was a consistently strong predictor in each.

The lack of difference between density levels is consistent with the results of Study I and of Anderson and Reder's (1980; 1982) research. An advantage of the low-density text was the significant reduction in lesson time without an associated reduction in learning. Results of the LC comparisons further suggested that learners are capable of making appropriate decisions when selecting contextual lesson attributes such as presentation mode or text density level. This finding is in contrast to negative results from LC applications which required learners to select the sequence, difficulty, or the amount of instructional support they needed to achieve objectives (Hannafin, 1984). Accordingly more skilled readers tended to select low-density text while less skilled readers tended to select high-density text, seemingly desirable strategies for both groups. This pattern coupled with the tendency to vary selections across lessons, suggests that the subjects attempted to adapt instructional demands to match specific needs as learning occurred.

Study III

A confounding variable in the CBI density comparisons of Studies I and II was screen density, the proportion of the display area containing characters as opposed to white space. Specifically, the frame structures into which the high- and low-density lessons were logically organized naturally resulted in sparser screens with the latter (low-density) material. Were the reactions to the density variations by LC-subjects primarily determined by the reduced content (text density) or by the less cluttered screens (screen density)?. As a first step toward answering this question, Study III was designed to examine what screen density levels for displaying textual material are most appealing to learners.

Prior research in the area of human factors engineering has produced several recommendations on this issue. Screen density is the amount of the screen actually used to display text or graphics, for example, a 40-column by 24-row screen can display a maximum of 960 characters. Danchak (1976) recommends a maximum screen density of 25% while most screens judged as "good" had a density of 15%. NASA (1980) recommends that screen density not exceed 60%. Smith (1980; 1981; 1982) recommends a maximum screen density of 31.2% and a minimum of 15.6% for 80 column screens.

Using these recommendations as a guide, we designed a study to determine which density level was most preferred by our learners. A possible limitation in typical studies of screen density preferences is the procedure of having subjects react to isolated, individual screens represented in the different density gradients. In cases, such as Grabinger's (1983) study, symbolic notation (Twyman, 1981) rather than approximations to English (c.f. Morrison, 1986), or actual lesson content comprises the "text." Would format preferences be the same with realistic content than with artificial prototypes? More specifically, in actual lessons, creating sparcer displays will necessarily require a greater number of screens. Does low-screen density seem as attractive to the student considering that tradeoff?

Subjects in this preliminary experiment were 35 education majors consisting of 14 undergraduates and 21 graduate students, and 26 females and 9 males. The stimulus materials consisted of the same text content (from the central tendency lesson) presented in four different screen density levels. The "conventional" frame consisted of definitions of mean, median, and mode (see Figure 2) presented on a single frame. When counting all letters and spaces contiguous with letters, the screen represented a density of 53%. This screen was then systematically divided into logical chunks to produce screens representing densities of 31%, 26%, and 22%. The text for 31% density required two screens, the 26% density required 3 screens, and the 22% density required 4 screens. It should be noted that the inclusion of additional screens to maintain equivalent content across variations presents a contrast with typical methodologies in which individual screens (an thus, varied amounts of total content) are judged. A paired-comparison design (Nunnally, 1967) was employed involving a total of 6 comparisons presented in random order on an Apple //e monochrome screen.

Insert Figure 2 about here

The data were scaled using the procedures described by Thurstone (1927). Results as shown in Figure 3, indicated that the 31% density level was preferred over the other 3 density levels ($p < .10$). Interestingly, these results suggest that subjects prefer to read two screens of information (31% density level) as opposed to 1 screen with the 53% density level. Similarly, subjects may have felt there was too little information on the 26% (3 screens) and 22% (4 screens) density screens for the effort of paging through the information. The 31% density level may provide an optimum density level which allows the designer to make effective use of both horizontal and vertical typography to organize the material into a pleasing screen.

Insert Figure 3 about here

Discussion

In this closing section of the paper we will discuss implications of our studies of screen and text density in CBI. The three areas addressed are screen design, learner control, and adaptive design strategies.

Screen Design

The CBI screen presents the designer with a format that imposes several limitations not found in printed text, yet it offers several new possibilities for the display of instructional information. Specifically, computer screens offer alternatives for gaining and redirecting attention, and cueing (flashing, inverse type, animation, and sound). Computer displays are dynamic in that a designer can build a screen in segments to emulate the content's structure, or reconstruct only parts of a screen for comparisons. The unique limitation of the CBI frame is the amount of information that can be displayed with a 40 or 80 column by 24 row grid. Following a traditional page format for CBI frames results in either very dense displays or inordinately long lessons. Such designs have prompted Tullis (1981) and Kerr (1986) to suggest research is needed to determine the appropriate amount of text density for screen displays.

Our research on low-density text suggests that this format is a viable alternative to the standard text format used in printed materials. A frame designed with low-density text can incorporate white space, double-spacing, and headings adequately in a single frame. This leaner screen provides the designer with the space needed to organize text which increases its visual appeal (Grabinger, 1985), while minimizing the total number of screens required to present the same content, another attractive feature (see Study III). Ample use of white space, and vertical and horizontal typography with low-density text will typically produce a unit of instruction that is comparable in frame length to the high-density text, but with approximately 50% fewer words. Our research found the low-density text was read faster and perceived as more sufficient than the same text presented in a print format.

Learner Control

Research on learner control (e.g., Tennyson, 1980; Ross & Rakow, 1981; 1982; Hannafin, 1984) has previously employed learner selections of the amount or difficulty of instructional support needed to achieve objectives. Learners were frequently found to make both inefficient and inappropriate choices, with high achievers selecting too much support and low-achievers too little. In contrast, text density simply manipulates the context of the lesson information as opposed to the number of examples or elaborations presented. Thus, it comprises a "stylistic" property of the lesson which LC subjects could vary based on preferences and reading skills, without necessarily having high abilities in or previous experience with the subject being taught.

Our research on learner control using text density as the decision variable, found the learner control groups learned better than groups receiving standard materials. The results indicated that the less skilled readers typically selected high-density text while the skilled reader selected low-density text. Implications from these results with information that that subjects varied their selections across units suggests that text density and other contextual variables can be used as an effective learner control variable in CBI (see also Ross, 1983).

Text Density as an Adaptive Strategy

Future research should further investigate the use of text density as a learner-control variable versus the use of program control or advisement. Such research holds the potential for developing prescriptions for text density based on levels of prior achievement and reading ability to provide for more efficient instruction. For example, initial text density levels could be established on the basis of a pretask measures so as to match the density level with the learner's characteristics. Text density could also be adapted online using procedures similar to those described by Tennyson (1984) in the MAIS. Again, the initial text density level could be established on the basis of prior experience or reading ability. During the lesson, the management system would monitor performance and time-on-task, and use the data to make appropriate changes in density level throughout the lesson. If a student were taking longer than the established mean, the management program might switch to low-density to improve the student's efficiency. Other research might investigate the use of high-density text during the initial stages of the lesson and then the gradual transition to low-density text as learner performance improves.

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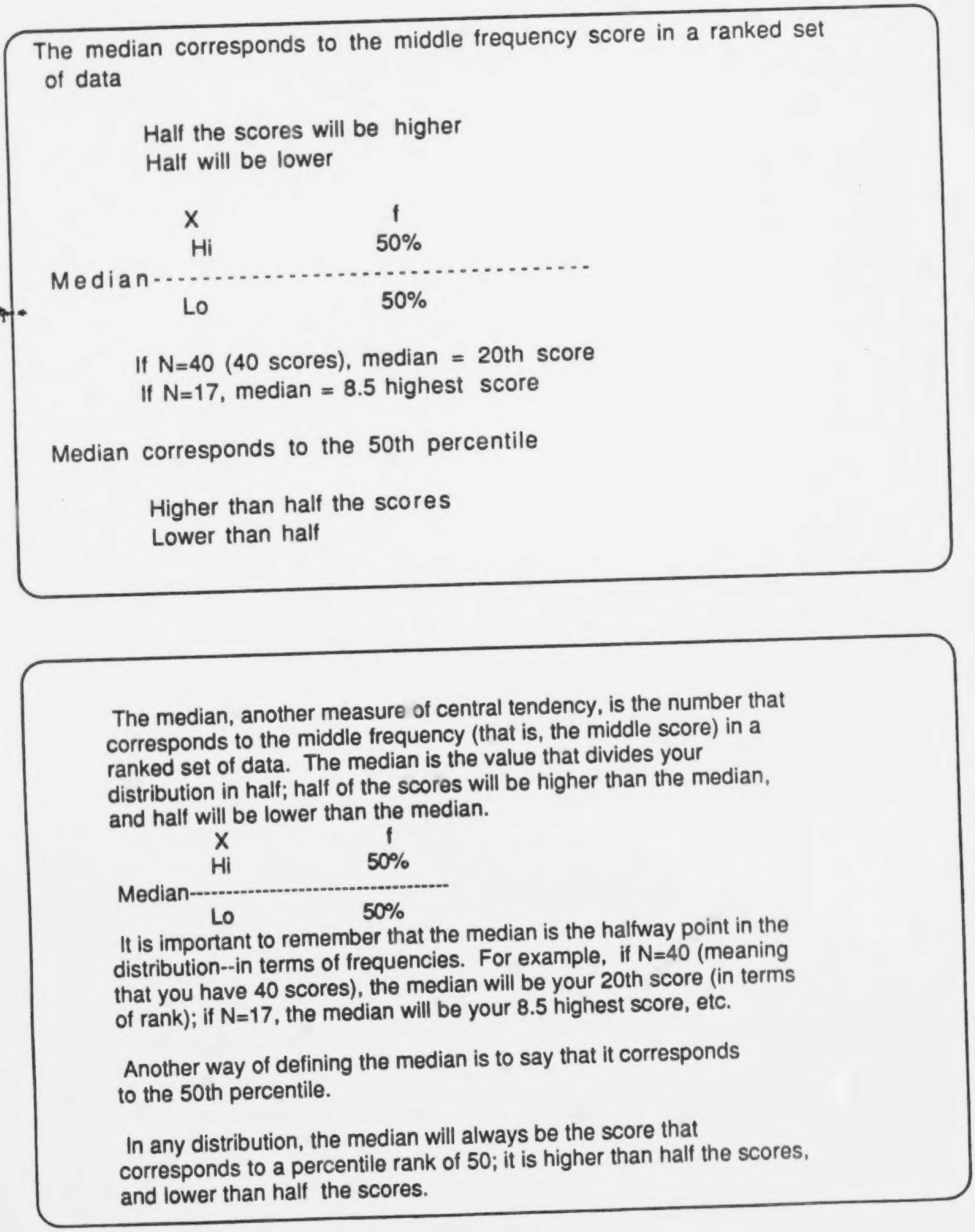

The median corresponds to the middle frequency score in a ranked set of data

Half the scores will be higher
Half will be lower

X	f
Hi	50%
Median------------------------------------	
Lo	50%

If N=40 (40 scores), median = 20th score
If N=17, median = 8.5 highest score

Median corresponds to the 50th percentile

Higher than half the scores
Lower than half

The median, another measure of central tendency, is the number that corresponds to the middle frequency (that is, the middle score) in a ranked set of data. The median is the value that divides your distribution in half; half of the scores will be higher than the median, and half will be lower than the median.

X	f
Hi	50%
Median------------------------------------	
Lo	50%

It is important to remember that the median is the halfway point in the distribution--in terms of frequencies. For example, if N=40 (meaning that you have 40 scores), the median will be your 20th score (in terms of rank); if N=17, the median will be your 8.5 highest score, etc.

Another way of defining the median is to say that it corresponds to the 50th percentile.

In any distribution, the median will always be the score that corresponds to a percentile rank of 50; it is higher than half the scores, and lower than half the scores.

Figure 1. Sample text density screens.

Tennyson, R.D., & Rothen, W. (1977). Pretask and on-task adaptive design strategies for selecting number of instances in concept acquisition. Journal of Educational Psychology, 5, 126-134.

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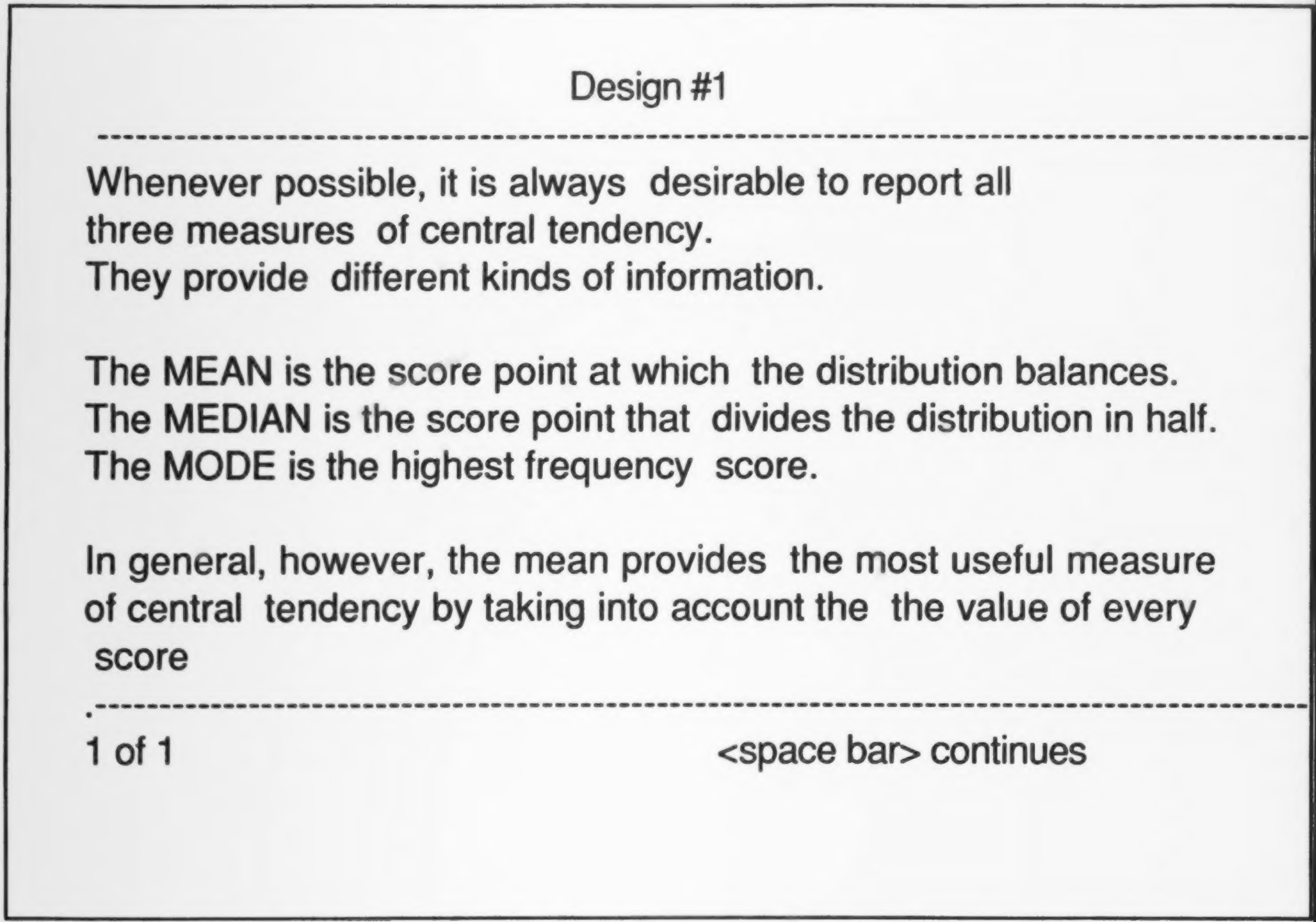

Design #1

Whenever possible, it is always desirable to report all
three measures of central tendency.
They provide different kinds of information.

The MEAN is the score point at which the distribution balances.
The MEDIAN is the score point that divides the distribution in half.
The MODE is the highest frequency score.

In general, however, the mean provides the most useful measure
of central tendency by taking into account the the value of every
score

1 of 1 <space bar> continues

Figure 2. Sample screen density.

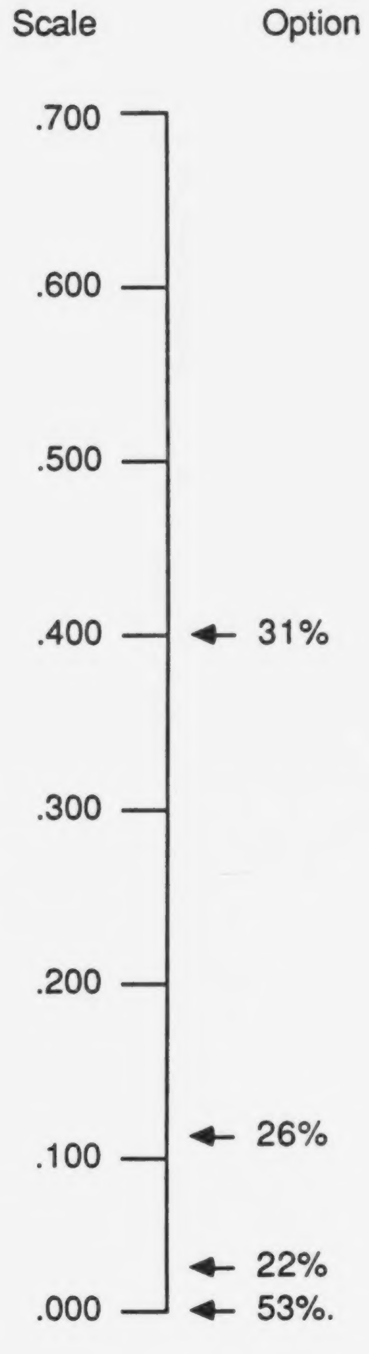

Figure 3. Scale of screen density preference

Title:

A Comparison of the Effects of Locus of Control with Feedback Strategies on Factual Information Recall and Retention During Computer Assisted Instruction

Author:

Sue Nishikawa

A comparison of the effects of locus of control with feedback strategies on factual information recall and retention during computer assisted instruction

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Abstract

While the microcomputer has the potential of becoming a most effective teaching tool/aid, many studies reveal no significant differences in learning occurring due to instruction by microcomputer. It is believed that the design of current instructional software fails to accommodate major individual differences in learning styles. Locus of control (LOC) and its effect on learner performance during computer assisted instruction (CAI) given varied feedback strategies are investigated in this study. It is hypothesized that learners who attribute their failures and success to internal events (Internals) will perform best under delayed feedback conditions while those who attribute successes and failures to external events (Externals) will perform best given immediate feedback. In addition, it is hypothesized that there is significant interaction of feedback on LOC.

Junior high school students from three 8th and 9th grade classes were given the Intellectual Achievement Responsibility Questionnaire to determine LOC. Treatment consisted of giving immediate, delayed and no feedback during CAI to each group of students identified as having internal or external LOC. Tests for recall and retention were administered.

A t-test compared the means of performance scores (independent variable) on tests for recall (T1) and retention (T2) between the treatment groups (dependent variable); Immediate (IFB), Delayed (DFB) and No-feedback (NFB), for 2 LOC groups (dependent variable); Internal and External. A 2x3 multivariate analysis of variance (MANOVA) tested for significance of interaction between the three feedback conditions and LOC. The results indicated the Internals performed significantly better than the Externals on DFB on the test for recall. No other significant differences or interaction were found.

A comparison of the effects of locus of control with feedback strategies on factual information recall and retention during computer assisted instruction

Introduction

Of all of the recent innovations in education, the microcomputer possesses those attributes which most closely resemble the human instructor. One of the most exciting features offered by this technology is its capability of interacting with the learner. The learner is no longer passive, but active. Moreover, the microcomputer can present information, ask questions, enable the student to respond, give feedback, correct errors and it can even remember names.

Most often cited as a great advantage of the microcomputer is its ability to give immediate feedback. The assumption appears to be that giving immediate feedback is critical in learning. However, while the behaviorists fully support the immediate feedback/reinforcement theory of learning, many studies argue that delayed feedback or no feedback may be more effective feedback strategies.

As important as strategies are, however, studies show that unless the learner is motivated learning will not occur. Motivation may be external and internal, however more specifically it is the learner's perception of the events that cause success or failure and the control he has over those events that seem to determine the amount of learning that occurs. Studies show that learners who feel responsible for their own successes and failures perform better given delayed feedback or no feedback while those who feel other persons and events are responsible for their successes and failures have been found to perform better given immediate feedback.

Background

In instructional design, assessing the learner is stressed (Heinich & Molenda, 1985; Kemp & Dayton, 1985; Locatis & Atkinson, 1984), however the underlying assumption in a majority of CAI programs available for use in the classroom today is that most learning is achieved through the use of small steps and immediate feedback (Nishikawa, 1987). Ploch (1986) places partial responsibility for this inconsistency upon the developers of software who are usually computer programmers and not educators.

Feedback strategies

Behaviorists claim immediate feedback/reinforcement to be appropriate for all instruction (Skinner, 1954). Others (Waldrop, Justen & Adams, 1986; Kulhavy, 1977; Surber & Anderson, 1975; Sassenrath, 1975; Sassenrath and Yonge, 1968, 1969) argue that delayed feedback may be as effective and more efficient than immediate feedback . Moreover, Karraker (1967) and Lublin (1965) have found that with particular types of learners under certain learning conditions, no feedback may be a more appropriate strategy. Kulhavy (1977) theorizes that "interference due to error perseveration is reduced if people are given a chance to forget incorrect responses" (p. 223) Studies determining the effectiveness of specific types and amount of feedback have produced mixed results (Merrill, 1987; Renzi, 1974; Block & Tierney, 1974; Tait, Hartley & Anderson, 1973). Annett (1969) attributes the difficulty of conducting such efforts to the transformations that have evolved over the past few decades in educational psychology particularly in feedback.

Skinner (1954) described feedback within a simple stimulus-response paradigm. However, feedback is now believed by some researchers (Powers, 1973) to be behavior in itself. Powers (1973) theorizes that "stimuli depend on responses according to the current organization of the environment and the body in which the nervous system resides" (p. 178) and that an individual knows nothing of his own behavior but the feedback effects of his own output. Therefore, according to Powers (1973), feedback is behavior.

Feedback and locus of control

Concurrent with Powers' position, Snow and Salomon (1968) maintain that learning variables within an individual function selectively and that an individual's development is a critical learning factor. Bar-Tal and Bar-Zohar (1977) in their review of 36 studies on the relationship of perception of control and achievement report a firm trend suggesting that for persons attributing failures and successes to self achievement was higher. When Baron and Ganz (1972) and associates (Baron, Cowan, Ganz & MacDonald, 1972) studied various feedback strategies using academic achievement as a dependent variable, significant differences were found between those identified as attributing the consequences of their behavior on external events (Externals) and those who accepted the responsibility for their successes and failures (Internals). It is suggested that by early adolescence the effect of intrinsic and extrinsic feedback is generally governed by variations in locus of control (LOC). Louie, Luick and Louie (1985-86) also contend that these perceptions will vary from person to person and within an individual over time.

Feedback and CAI

More recently educational research has attempted to determine the effectiveness of the microcomputer used in the instructional environment. Some researchers (Tait et al, 1973; Cohen, 1985; Albertson, 1986) claim instructional design of CAI generally inferior as reliance is placed on outmoded theories and practice. Carrier (1985) emphasizes that educators must take advantage of the microcomputer's ability to collect data, respond appropriately, diagnose needs, prescribe instruction, simulate activities and evaluate sequences among other characteristics to meet individual learning needs.

The study of feedback strategies in instruction by microcomputer is still in its infancy. In one study, Cohen (1985) discovered that the greatest effect on performance resulted from information feedback given after incorrect responses. Feedback after correct responses was reportedly unimportant to students in certain cases. Cohen (198t) posits that feedback after a correct response may cause interference in learning, particularly with those students who maintain high confidence in their knowledge of the material. Immediate feedback seemed most effective only in knowledge acquisition for those students having difficulty mastering the material.

In a later study, Waldrop, Justen and Adams (1986) varied the amount of corrective feedback during drill and practice in CAI and found that immediate extended feedback following both correct and incorrect responses is superior to minimal feedback or simply acknowledging right or wrong responses. On the other hand delayed feedback in CAI was found to be significantly better than immediate feedback in a study by Rankin and Trepper (1978).

Locus of control and CAI

Cohen (1985) alludes to a relationship between high confidence in the knowledge of the material to be learned and the need for feedback. Students having difficulty mastering the material seemed to perform better given immediate feedback.

Louie et al. (1985-86) studied 46 students, 9 to 15 years of age, of high socioeconomic status to determine whether by using Logo and Bank Street Writer there would be a shift in LOC. While the results are questionable, significant shifts were found in LOC. In a study by Wesley et al. (1985), however, no main effects and no interaction of LOC and acquisition of science process skills during CAI.

As the use of microcomputers increases, concepts such as reinforcement, feedback and LOC need to be more clearly defined Louie et al. (1985-86) states that "if locus of control does play a significant part in the child's interpretation of reinforcement and its relationship to events occurring in reality, then software design should be influenced in the light of such research findings" (p.107).

The need for feedback in CAI studies is strongly urged by Gilman (1969) and others (Cohen, 1985; Hedberg and McNamara, ; Merrill, 1983, 1987). Furthermore, Merrill (1987) and Cohen (1985) express the need for better and more efficient CAI.

The new technology demands that developers of instruction integrate current research findings related to cognition and instruction (Costa, 1980) into instructional design of CAI. With the high potential the microcomputer holds as a teaching/learning tool expanded by the ease of current assuring systems, the possibility of designing diverse instruction to meet specific individual needs is now possible.

The study

Purpose

This study was designed to examine the effects of immediate, delayed and no feedback conditions on recall and retention in a computer based instruction and to determine whether an individual's LOC significantly interacts to affect performance.

It was hypothesized that:

1. Given immediate feedback, the Externals (learners identified as having external LOC) will perform significantly better than the Internals (learners identified as having internal LOC) on the tests for recall and retention.
2. Given delayed feedback, the Internals will perform significantly better than Externals on the tests for recall and retention.
3. Given no feedback, the Internals will perform significantly better than Externals on the tests for recall and retention.
4. Significant interaction will be found between LOC measures and the feedback conditions.

Location

The study was conducted at a junior high school in a midwestern, suburban community of approximately 60,000. The school serves a middle to upper middle social-economic population.

Subjects

Subjects were 37 students in two 9th grade and one 8th grade Social Studies classes, 23 males and 14 females.

Microcomputers

Twelve Apple II and IIe microcomputers in the school's Microcomputer lab were used in the study. The arrangement of the equipment permitted students to work independently.

Questionnaire

The Intellectual Achievement Responsibility Questionnaire (IARQ) developed by Crandall, Katkovsky and Crandall (1965) was used to measure students' beliefs that failures and successes in achievement are caused by internal or external factors. The instrument has acceptable reliability, both divergent and convergent validity (MacDonald, 1973) and contains 34 forced-choice items. A total of 24 or less identified the students as having external LOC and 26 or more, internal LOC.

Computer assisted instruction (CAI)

The same instructional sequence was presented under three different conditions: immediate, delayed and no feedback. The lessons were created using Super-Pilot, an Apple authoring software package. In order that the instruction could be easily completed during one 50-minute period, each program consisted of 28 frames taking about 20 minutes.

Immediate feedback condition

The CAI program presented text and graphics. At the end of each step, the student responded to a question relative to the information, was given praise/acknowledgment of correctness/incorrectness of answer, was remediated if incorrect, then instructed to continue.

Delayed feedback condition

The CAI program presented identical text and graphics. The student was informed in the introduction to the lesson that responses to questions would not be acknowledged at the end of each step but would be delayed until the end of the lesson. Therefore, at the end of each step, the student responded to a question relative to the information but was not given feedback before being instructed to continue.

No-feedback condition

The CAI program presented identical text and graphics. The student was informed in the introduction to the lesson that responses to questions would not be acknowledged. At the end of each step the student was given the option to respond or not respond then instructed to continue.

Immediate test for recall

A 15-item paper and pencil test was given immediately after the CAI instruction.

One week test for retention

A similar 15-item paper and pencil test was given a week after the CAI instruction.

Experimental schedule

The IARQ was administered one week prior to the CAI testing. Students were divided into two LOC groups according to scores on the IARQ with Internals scoring 26 and above and Externals scoring 24 and less on a scale from 1-34. Each LOC group was further subdivided into three treatment groups, IFB, DFB and NFB.

On the day of the instruction, students received individual lesson diskettes identified by previously assigned identification numbers before proceeding to the microcomputers. Since there was general familiarity with the use of the equipment, students were asked to "boot" the program by simply inserting the diskette into the disk drive and turning on the power switch. Each of the programs directed the students to raise their hands upon completion of the instruction to signify readiness for the test for recall.

Once the test was completed, the students returned to the classroom. Two days following the instruction each student received the results of the test and corrective information to those items missed on the test. Seven days following the initial test, a paper and pencil test for retention was administered. Confidentiality was preserved by teacher assigned identification numbers.

Analysis of data

Performance scores on the tests for recall (T1) and retention (T2) and locus of control, Internal and External, were the dependent measures. The treatment, consisting of of immediate (IFB), delayed (DFB) and no-feedback (NFB) conditions, was the independent measure. t-tests were performed to detect the presence of significant differences between the means of the treatment groups for the Internal and External measures. The 2x3 multivariate analysis of variance (MANOVA) was used to test for interaction between LOC and feedback.

Results

The summary of cell means and standard deviations for the variables are presented in Table 1. The test for recall (T1) and retention (T2) were scored on the basis of number of correct answers out of a possible maximum of 15 items for each test. Locus of control was determined by scores on the IARQ with Internals scoring 26 and more and Externals scoring 24 and less on a scale from 1-34.

Insert Table 1 here

Hypothesis 1. Given immediate feedback, the Externals will perform significantly better than Internals on tests for recall and retention during CAI.

The t-test used to compare the means of performance scores of the IFB condition on the Internals and Externals indicated no significant difference on T1, $t(11)=-0.11$, or T2, $t(8)=-0.71$.

Insert Table 2 here

Hypothesis 2. Given delayed feedback, the Internals will perform significantly better than Externals on tests for recall and retention during CAI.

The t-tests used to compare the means of performance scores of the DFB condition on the Internals and Externals indicated a significant difference in performance for T1, $t(12)=1.90$, $p<.04$. No significant difference was noted in T2, $t(12)=1.56$ (Table 2)

Hypothesis 3. Given no feedback, the Internals will perform significantly better than the Externals on tests for recall and retention.

The t-test used to compare the means of performance scores of the NFB condition on the Internals and Externals indicated no significant difference on T1, $t(11)=0.08$, or on T2, $t(11)=-1.64$ (Table 2).

Hypothesis 4. Significant interaction will be found between LOC measures and feedback conditions.

Neither the test on the univariate (Table 3) nor the MANOVA using Wilk's test of significance (Table 4) indicates the presence of any interaction between LOC and feedback conditions.

Discussion

The results of the t-tests performed on the treatment variables provide no support of the hypotheses that immediate feedback or no-feedback are more effective conditions or that they are better instructional strategies for either Internal or External LOC learners. However, the significant difference found between the performance of Internals and Externals under DFB conditions (p=<.04) indicates LOC learners would be more likely to show better performance under delayed feedback conditions than from either immediate or no feedback conditions.

In earlier LOC by academic achievement studies, Crandall and Battle (1970), Baron and Ganz (1974) and Bar-Tal and Bal-Zohar (1977), have found that high achievers are generally Internals. In addition feedback studies show delayed feedback to be more effective for certain individuals (Kulhavy, 1977; Rankin & Trepper, 1978).

If, indeed, the data support the hypothesis that given delayed feedback Internals will perform better than Externals, it could provide some insight into the type of individual who benefits from delayed feedback. Kulhavy's (1977) "interference due to error perseveration" phenomenon (p. 223) could well be a characteristic of the cognitive process experienced by the Internal.

Drawing conclusions regarding achievement and locus of control from this study or any study must be done cautiously (Stipek, 1980), however. It is the contention of researchers that in addition to flaws in research design and procedure there are other variables such as socioeconomic conditions (Crandall, Katkovsky & Crandall, 1965), race (Baron et al., 1974), and sex (Louie et al., 1985-86) which operate to confound any set of data.

While comparable results are described in other studies in feedback strategies in instruction and the effect of locus of control in academic achievement (Beck & Lindsey, 1979; Kulhavy, White, Topp, Chan & Adams, 1985; Bar-Tal & Bar Zohar, 1977) major limitations contributed to the contamination of the present study.

1. Small sample size

A larger sample would indeed have increased the power of the study. Keppel (1982) suggests that a 2x3 factorial design have at least 20 subjects per cell. Although contact was made with 79 students in this study, only 37 completed all phases of the study. Absences and inattentiveness were primary causes of attrition.

2. Limited instructional time

Permission to conduct the study in a junior high school classroom was obtained contingent upon an agreement that the IARQ, the lesson, and tests for recall and retention take no longer than 70 minutes on three given days, 10 minutes for the IARQ, 50 minutes for instruction and 10 minutes for the retention test. Instruction over a longer period of time would have produced more significant data.

3. Short CAI program

In order that the students spend no more than 50 minutes in the microcomputer lab, it was necessary to limit the CAI program to 28 frames which took approximately 20 minutes for the students to complete. The narrow range of performance values did not provide an accurate profile of knowledge acquisition or retention.

4. Instruction not a part of the classroom curriculum

The awareness that the lesson would not affect students' grades appeared to have impact on attitude toward the instruction. Obvious signs of relief were observed when students were told the tests would not be graded.

Conclusions

In spite of the four limitations cited, two conclusions are made. The first relates to the hypotheses and the second to experimental design.

The data indicates a need for further research on the effectiveness of delayed feedback for internal LOC learners. Out of the four hypotheses presented, the results showed support only for the delayed feedback as an effective strategy for learners who are identified as Internals.

From this study it is concluded that in conducting research of this nature, it would be valuable for researchers to be aware of the processes involved in obtaining data from school children and the yield from such studies. It should be noted that seven levels of approval had to be met before experimentation could begin and that the attrition rate was 53% which yielded 37 usable data. Information of this sort is just as necessary in interpreting the results of studies such as this as are statistical data.

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Table 1

Summary of cell means and standard deviations of Immediate (IFB), Delayed (DFB) and No-feedback (NFB) treatment groups on LOC groups

TEST FOR RECALL (T1)

LOC	Treatmt	Mean	S.D.	N	95% Conf. Interval	
Internal	IFB	12.714	2.360	7	10.531	14.897
	DFB	13.556	1.424	9	12.461	14.650
	NFB	12.429	2.070	7	10.514	14.343
External	IFB	12.667	1.528	3	8.872	16.416
	DFB	11.200	3.271	5	7.138	15.262
	NFB	12.333	2.503	6	9.706	14.960
Entire Sample		12.595	2.192	37	11.864	13.325

TEST FOR RETENTION (T2)

LOC	Treatmt	Mean	S.D.	N	95% Conf. Interval	
Internal	IFB	8.429	2.225	7	6.370	10.487
	DFB	10.667	1.581	9	9.451	11.882
	NFB	7.857	1.676	7	6.307	9.407
External	IFB	9.667	3.215	3	1.681	17.652
	DFB	9.000	2.449	5	5.959	12.041
	NFB	9.833	2.639	6	7.063	12.603
Entire Sample		9.270	2.269	37	8.514	10.027

Table 2

Summary of cell means, standard deviations and t-test of IFB, DFB and NFB on Internal and External LOC

TEST FOR RECALL (T1)

Immediate

LOC	N	Mean	S.D.	t-Value	df
Internal	7	12.714	2.360	-0.11	11
External	3	12.667	1.528		
Total	10	12.700			
Mean Difference		0.047			

Delayed

LOC	N	Mean	S.D.	t-Value	df
Internal	9	13.556	1.424	-1.90*	12
External	5	11.200	3.271		
Total	14	12.715			
Mean Difference		2.356			

No-feedback

LOC	N	Mean	S.D.	t-Value	df
Internal	7	12.429	2.070	0.08	11
External	6	12.333	2.503		
Total	13	12.384			
Mean Difference		0.096			

TEST FOR RETENTION (T2)

Immediate

LOC	N	Mean	S.D.	t-Value	df
Internal	7	8.429	2.225	-0.71	8
External	3	9.667	3.215		
Total	10	8.800			
Mean Difference		1.238			

Delayed

LOC	N	Mean	S.D.	t-Value	df
Internal	9	10.667	1.581	1.56	12
External	5	9.000	2.419		
Total	14	10.072			
Mean Difference		1.667			

No-Feedback

LOC	N	Mean	S.D.	t-Value	df
Internal	7	7.857	1.676	-1.64	11
External	6	9.833	2.639		
Total	13	8.769			
Mean Difference		1.976			

Table 3

Test of significance of interaction between Internal and External LOC and treatment conditions on the univariate

TEST FOR RECALL (T1)

Factor	df	SS	MS	F	Signif. of F
LOC	1	5.691	5.691	1.144	.293
Treatment	2	.613	.307	.062	.940
LOC x Treatment	2	10.418	5.209	1.047	.363

TEST FOR RETENTION (T2)

Factor	df	SS	MS	F	Signif. of F
LOC	1	2.184	2.184	.463	.501
Treatment	2	6.827	3.413	.724	.493
LOC x Treatment	2	23.225	11.612	2.464	.102

Table 4

Wilk's multivariate test of significance for LOC, Treatment and LOC x Treatment

Factor	Value	df	F	Signif. of F
LOC	.889	2	1.873	.171
Treatment	.920	4	.637	.645
LOC x Treatment	.859	4	1.181	.328

Title:

Effects of Feedback Strategies in Computer Assisted Instruction and the Influence of Locus of Control on the Performance of Junior High Students

Author:

Sue Nishikawa

Effects of feedback strategies in computer assisted instruction and the influence of locus of control on the performance of junior high students

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Abstract

While the microcomputer has the potential of becoming a most effective teaching tool/aid, many studies reveal no significant differences in learning occurring due to instruction by microcomputer. It is believed that the design of current instructional software fails to accommodate major individual differences in learning styles. Locus of control (LOC) and its effect on learner performance during computer assisted instruction (CAI) given varied feedback strategies are investigated in this study.

It is hypothesized that learners who attribute their failures and successes to internal events (Internals) will perform best under delayed feedback conditions while those who attribute successes and failures to external events (Externals) will perform best given immediate feedback. In addition, it is hypothesized that there is significant interaction of feedback on LOC.

Junior high school students from three 8th and 9th grade classes were given the Intellectual Achievement Responsibility Questionnaire to determine LOC. Treatment consisted of giving immediate, delayed and no feedback during CAI to each group of students identified as having internal or external LOC. Tests for recall and retention were administered.

A t-test compared the means of performance scores (independent variable) on tests for recall (T1) and retention (T2) between the treatment groups (dependent variable); Immediate (IFB), Delayed (DFB) and No-feedback (NFB), for two LOC groups (dependent variable); Internal and External. A 2x3 multivariate analysis of variance (MANOVA) tested for significance of interaction between the three feedback conditions and LOC. The results indicated the Internals performed significantly better than the Externals on DFB on the test for recall. No other significant differences or interaction were found.

Effects of feedback strategies in computer assisted instruction and the influence of locus of control on the performance of junior high students

Introduction

Of all of the recent innovations in education, the microcomputer possesses those attributes which most closely resemble the human instructor. One of the most exciting features offered by this technology is its capability of interacting with the learner. The learner is no longer passive, but active. Moreover, the microcomputer can present information, ask questions, enable the student to respond, give feedback, correct errors and it can even remember names.

Most often cited as a great advantage of the microcomputer is its ability to give immediate feedback. The assumption appears to be that giving immediate feedback is critical in learning. However, while the behaviorists fully support the immediate feedback/reinforcement theory of learning, many studies argue that delayed feedback or no feedback may be more effective feedback strategies.

As important as strategies are, however, studies show that unless the learner is motivated learning will not occur. Motivation may be external and internal, however more specifically it is the learner's perception of the events that cause success or failure and the control he has over those events that seem to determine the amount of learning that occurs. Studies show that learners who feel responsible for their own successes and failures perform better given delayed feedback or no feedback while those who feel other persons and events are responsible for their successes and failures have been found to perform better given immediate feedback.

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When Baron and Ganz (1972) and associates (Baron, Cowan, Ganz & MacDonald, 1972) studied various feedback strategies using academic achievement as a dependent variable, significant differences were found between those identified as attributing the consequences of their behavior on external events (Externals) and those who accepted the responsibility for their successes and failures (Internals). It is suggested that by early adolescence the effect of intrinsic and extrinsic feedback is generally governed by variations in locus of control (LOC). Louie, Luick and Louie (1985-86) also contend that these perceptions will vary from person to person and within an individual over time.

Feedback and CAI

More recently educational research has attempted to determine the effectiveness of the microcomputer used in the instructional environment. Some researchers (Tait et al, 1973; Cohen, 1985; Albertson, 1986) claim instructional design of CAI generally inferior as reliance is placed on outmoded theories and practice. Carrier (1985) emphasizes that educators must take advantage of the microcomputer's ability to collect data, respond appropriately, diagnose needs, prescribe instruction, simulate activities and evaluate sequences among other characteristics to meet individual learning needs.

The study of feedback strategies in instruction by microcomputer is still in its infancy. In one study, Cohen (1985) discovered that the greatest effect on performance resulted from information feedback given after incorrect responses. Feedback after correct responses was reportedly unimportant to students in certain cases. Cohen (1985) posits that feedback after a correct response may cause interference in learning, particularly with those students who maintain high confidence in their knowledge of the material. Immediate feedback seemed most effective only in knowledge acquisition for those students having difficulty mastering the material.

In a later study, Waldrop, Justen and Adams (1986) varied the amount of corrective feedback during drill and practice in CAI and found that immediate extended feedback following both correct and incorrect responses is superior to minimal feedback or simply acknowledging right or wrong responses. On the other hand delayed feedback in CAI was found to be significantly better than immediate feedback in a study by Rankin and Trepper (1978).

Locus of control and CAI

Cohen (1985) alludes to a relationship between high confidence in the knowledge of the material to be learned and the need for feedback. Students having difficulty mastering the material seemed to perform better given immediate feedback.

Louie et al. (1985-86) studied 46 students, 9 to 15 years of age, of high socioeconomic status to determine whether by using Logo and Bank Street Writer there would be a shift in LOC. While the results are questionable, significant shifts were found in LOC. In a study by Wesley et al. (1985), however, no main effects and no interaction of LOC and acquisition of science process skills during CAI.

As the use of microcomputers increases, concepts such as reinforcement, feedback and LOC need to be more clearly defined Louie et al. (1985-86) states that "if locus of control does play a significant part in the child's interpretation of reinforcement and its relationship to events occurring in reality, then software design should be influenced in the light of such research findings" (p.107).

The need for feedback in CAI studies is strongly urged by Gilman (1969) and others (Cohen, 1985; Hedberg and McNamara, ; Merrill, 1983, 1987). Furthermore, Merrill (1987) and Cohen (1985) express the need for better and more efficient CAI.

The new technology demands that developers of instruction integrate current research findings related to cognition and instruction (Costa, 1980) into instructional design of CAI. With the high potential the microcomputer holds as a teaching/learning tool expanded by the ease of current assuring systems, the possibility of designing diverse instruction to meet specific individual needs is now possible.

The study

Purpose

This study was designed to examine the effects of immediate, delayed and no feedback conditions on recall and retention in a computer based instruction and to determine whether an individual's LOC significantly interacts to affect performance.

It was hypothesized that:

1. Given immediate feedback, the Externals (learners identified as having external LOC) will perform significantly better than the Internals (learners identified as having internal LOC) on the tests for recall and retention.
2. Given delayed feedback, the Internals will perform significantly better than Externals on the tests for recall and retention.
3. Given no feedback, the Internals will perform significantly better than Externals on the tests for recall and retention.
4. Significant interaction will be found between LOC measures and the feedback conditions.

Location

The study was conducted at a junior high school in a midwestern, suburban community of approximately 60,000. The school serves a middle to upper middle social-economic population.

Subjects

Subjects were 37 students in two 9th grade and one 8th grade Social Studies classes, 23 males and 14 females.

Microcomputers

Twelve Apple II and IIe microcomputers in the school's Microcomputer lab were used in the study. The arrangement of the equipment permitted students to work independently.

Questionnaire

The Intellectual Achievement Responsibility Questionnaire (IARQ) developed by Crandall, Katkovsky and Crandall (1965) was used to measure students' beliefs that failures and successes in achievement are caused by internal or external factors. The instrument has acceptable reliability, both divergent and convergent validity (MacDonald, 1973) and contains 34 forced-choice items. A total of 24 or less identified the students as having external LOC and 26 or more, internal LOC.

Computer assisted instruction (CAI)

The same instructional sequence was presented under three different conditions: immediate, delayed and no feedback. The lessons were created using Super-Pilot, an Apple authoring software package. In order that the instruction could be easily completed during one 50-minute period, each program consisted of 28 frames taking about 20 minutes.

Immediate feedback condition

The CAI program presented text and graphics. At the end of each step, the student responded to a question relative to the information, was given praise/acknowledgment of correctness/incorrectness of answer, was remediated if incorrect, then instructed to continue.

Delayed feedback condition

The CAI program presented identical text and graphics. The student was informed in the introduction to the lesson that responses to questions would not be acknowledged at the end of each step but would be delayed until the end of the lesson. Therefore, at the end of each step, the student responded to a question relative to the information but was not given feedback before being instructed to continue.

No-feedback condition

The CAI program presented identical text and graphics. The student was informed in the introduction to the lesson that responses to questions would not be acknowledged. At the end of each step the student was given the option to respond or not respond then instructed to continue.

Immediate test for recall

A 15-item paper and pencil test was given immediately after the CAI instruction.

One week test for retention

A similar 15-item paper and pencil test was given a week after the CAI instruction.

Experimental schedule

The IARQ was administered one week prior to the CAI testing. Students were divided into two LOC groups according to scores on the IARQ with Internals scoring 26 and above and Externals scoring 24 and less on a scale from 1-34. Each LOC group was further subdivided into three treatment groups, IFB, DFB and NFB.

On the day of the instruction, students received individual lesson diskettes identified by previously assigned identification numbers before proceeding to the microcomputers. Since there was general familiarity with the use of the equipment, students were asked to "boot" the program by simply inserting the diskette into the disk drive and turning on the power switch. Each of the programs directed the students to raise their hands upon completion of the instruction to signify readiness for the test for recall.

Once the test was completed, the students returned to the classroom. Two days following the instruction each student received the results of the test and corrective information to those items missed on the test. Seven days following the initial test, a paper and pencil test for retention was administered. Confidentiality was preserved by teacher assigned identification numbers.

Analysis of data

Performance scores on the tests for recall (T1) and retention (T2) and locus of control, Internal and External, were the dependent measures. The treatment, consisting of of immediate (IFB), delayed (DFB) and no-feedback (NFB) conditions, was the independent measure. t-tests were performed to detect the presence of significant differences between the means of the treatment groups for the Internal and External measures. The 2x3 multivariate analysis of variance (MANOVA) was used to test for interaction between LOC and feedback.

Results

The summary of cell means and standard deviations for the variables are presented in Table 1. The test for recall (T1) and retention (T2) were scored on the basis of number of correct answers out of a possible maximum of 15 items for each test. Locus of control was determined by scores on the IARQ with Internals scoring 26 and more and Externals scoring 24 and less on a scale from 1-34.

Insert Table 1 here

Hypothesis 1. Given immediate feedback, the Externals will perform significantly better than Internals on tests for recall and retention during CAI.

The t-test used to compare the means of performance scores of the IFB condition on the Internals and Externals indicated no significant difference on T1, t(11)=-0.11, or T2, t(8)=-0.71.

Insert Table 2 here

Hypothesis 2. Given delayed feedback, the Internals will perform significantly better than Externals on tests for recall and retention during CAI.

The t-tests used to compare the means of performance scores of the DFB condition on the Internals and Externals indicated a significant difference in performance for T1, t(12)=1.90, $p<.04$. No significant difference was noted in T2, t(12)=1.56 (Table 2)

Hypothesis 3. Given no feedback, the Internals will perform significantly better than the Externals on tests for recall and retention.

The t-test used to compare the means of performance scores of the NFB condition on the Internals and Externals indicated no significant difference on T1, t(11)=0.08, or on T2, t(11)=-1.64 (Table 2).

Hypothesis 4. Significant interaction will be found between LOC measures and feedback conditions.

Neither the test on the univariate (Table 3) nor the MANOVA using Wilk's test of significance (Table 4) indicates the presence of any interaction between LOC and feedback conditions.

Discussion

The results of the t-tests performed on the treatment variables provide no support of the hypotheses that IFB or NFB during CAI of factual information are more effective conditions for recall and retention, or that they are better instructional conditions for either Internal or External LOC learners. However, the significant difference found between the performance of Internals and Externals under DFB conditions ($p=<.04$) indicates LOC learners would be more likely to show better performance under DFB conditions than from either IFB or NFB conditions.

In earlier LOC by academic achievement studies, Crandall and Battle (1970), Baron and Ganz (1974) and Bar-Tal and Bal-Zohar (1977), have found that high achievers are generally Internals. In addition feedback studies show delayed feedback to be more effective for certain individuals (Kulhavy, 1977; Rankin & Trepper, 1978).

If, indeed, the data support the hypothesis that given DFB Internals will perform better than Externals, it could provide some insight into the type of individual who benefits from DFB. Kulhavy's (1977) "interference due to error perseveration" phenomenon (p. 223) could be indicative of a characteristic of the cognitive process experienced by the Internal.

Drawing conclusions regarding achievement and locus of control during CAI from this study or any study must be done cautiously (Stipek, 1980), however. It is the contention of researchers that in addition to flaws in research design and procedure there are other variables such as socioeconomic conditions (Crandall, Katkovsky & Crandall, 1965), race (Baron et al., 1974), and sex (Louie et al., 1985-86) which operate to confound any set of data.

While comparable results are described in other studies in feedback conditions in instruction and the effect of locus of control in academic achievement (Beck & Lindsey, 1979; Kulhavy, White, Topp, Chan & Adams, 1985; Bar-Tal & Bar Zohar, 1977) major limitations contributed to the contamination of the present study.

1. Small sample size

A larger sample would indeed have increased the power of the study. Keppel (1982) suggests that a 2x3 factorial design have at least 20 subjects per cell. Although contact was made with 79 students in this study, only 37 completed all phases of the study. Absences and inattentiveness were primary causes of attrition.

2. Limited instructional time

Permission to conduct the study in a junior high school classroom was obtained contingent upon an agreement that the IARQ, the lesson, and tests for recall and retention take no longer than 70 minutes on three given days, 10 minutes for the IARQ, 50 minutes for instruction and 10 minutes for the retention test. Instruction over a longer period of time would have produced more significant data.

3. Short CAI program

In order that the students spend no more than 50 minutes in the microcomputer lab, it was necessary to limit the CAI program to 28 frames which took approximately 20 minutes for the students to complete. The narrow range of performance values did not provide an accurate profile of knowledge acquisition or retention.

4. Instruction not a part of the classroom curriculum

The awareness that the lesson would not affect students' grades appeared to have impact on attitude toward the instruction. Obvious signs of relief were observed when students were told the tests would not be graded.

Conclusions

In spite of the four limitations cited, two conclusions are made. The first relates to the hypotheses and the second to experimental design.

The data indicates a need for further research on the effectiveness of delayed feedback for internal LOC learners during CAI. Out of the four hypotheses presented, the results showed support only for the delayed feedback as an effective condition for learners who are identified as Internals.

From this study it is concluded that in conducting research of this nature, it would be valuable for researchers to be aware of the processes involved in obtaining data from school children and the yield from such studies. It should be noted that seven levels of approval had to be met before experimentation could begin and that the attrition rate was 53% which yielded 37 usable data. Information of this sort is just as necessary in interpreting the results of studies such as this as are statistical data.

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Table 1

Summary of cell means and standard deviations of Immediate (IFB), Delayed (DFB) and No-feedback (NFB) treatment groups on LOC groups

TEST FOR RECALL (T1)

LOC	Treatmt	Mean	S.D.	N	95% Conf.	Interval
Internal	IFB	12.714	2.360	7	10.531	14.897
	DFB	13.556	1.424	9	12.461	14.650
	NFB	12.429	2.070	7	10.514	14.343
External	IFB	12.667	1.528	3	8.872	16.416
	DFB	11.200	3.271	5	7.138	15.262
	NFB	12.333	2.503	6	9.706	14.960
Entire Sample		12.595	2.192	37	11.864	13.325

TEST FOR RETENTION (T2)

LOC	Treatmt	Mean	S.D.	N	95% Conf.	Interval
Internal	IFB	8.429	2.225	7	6.370	10.487
	DFB	10.667	1.581	9	9.451	11.882
	NFB	7.857	1.676	7	6.307	9.407
External	IFB	9.667	3.215	3	1.681	17.652
	DFB	9.000	2.449	5	5.959	12.041
	NFB	9.833	2.639	6	7.063	12.603
Entire Sample		9.270	2.269	37	8.514	10.027

Table 2

Summary of cell means, standard deviations and t-test of IFB, DFB and NFB on Internal and External LOC

TEST FOR RECALL (T1)

Immediate

LOC	N	Mean	S.D.	t-Value	df
Internal	7	12.714	2.360	-0.11	11
External	3	12.667	1.528		
Total	10	12.700			
Mean Difference		0.047			

Delayed

LOC	N	Mean	S.D.	t-Value	df
Internal	9	13.556	1.424	-1.90*	12
External	5	11.200	3.271		
Total	14	12.715			
Mean Difference		2.356			

* p=<.04

No-feedback

LOC	N	Mean	S.D.	t-Value	df
Internal	7	12.429	2.070	0.08	11
External	6	12.333	2.503		
Total	13	12.384			
Mean Difference		0.096			

TEST FOR RETENTION (T2)

Immediate

LOC	N	Mean	S.D.	t-Value	df
Internal	7	8.429	2.225	-0.71	8
External	3	9.667	3.215		
Total	10	8.800			
Mean Difference		1.238			

Delayed

LOC	N	Mean	S.D.	t-Value	df
Internal	9	10.667	1.581	1.56	12
External	5	9.000	2.419		
Total	14	10.072			
Mean Difference		1.667			

No-Feedback

LOC	N	Mean	S.D.	t-Value	df
Internal	7	7.857	1.676	-1.64	11
External	6	9.833	2.639		
Total	13	8.769			
Mean Difference		1.976			

Table 3

Test of significance of interaction between Internal and External LOC and treatment conditions on the univariate

TEST FOR RECALL (T1)

Factor	df	SS	MS	F	Signif. of F
LOC	1	5.691	5.691	1.144	.293
Treatment	2	.613	.307	.062	.940
LOC x Treatment	2	10.418	5.209	1.047	.363

TEST FOR RETENTION (T2)

Factor	df	SS	MS	F	Signif. of F
LOC	1	2.184	2.184	.463	.501
Treatment	2	6.827	3.413	.724	.493
LOC x Treatment	2	23.225	11.612	2.464	.102

Table 4

Wilk's multivariate test of significance for LOC, Treatment and LOC x Treatment

Factor	Value	df	F	Signif. of F
LOC	.889	2	1.873	.171
Treatment	.920	4	.637	.645
LOC x Treatment	.859	4	1.181	.328

Title:

An Instructional Theory for the Design of Computer-Based Simulations

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Ellen Schwartz

INSTRUCTIONAL DESIGN,
DEVELOPMENT,
AND EVALUATION

WORKING PAPERS

AN INSTRUCTIONAL THEORY FOR THE DESIGN OF COMPUTER-BASED SIMULATIONS

by

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IDD&E Working Paper No. 23
June, 1987

SCHOOL OF EDUCATION, SYRACUSE UNIVERSITY

Abstract

A simulation is described in terms of its three major design aspects: the scenario, the underlying model, and the instructional overlay. The major focus of this paper is on the instructional overlay which serves to optimize learning and motivation. The functions of simulations and the features that should be used to achieve these functions are described. Prescriptions for the design of computer-based simulations are presented in the form of a general model and variations on the general model. The general model offers prescriptions for the design of the introduction, acquisition, application, and assessment stages of simulations and for dealing with the issue of control (system or learner). Variations on the general model are based on the nature of the behavior (procedures, process principles, and causal principles), complexity of the content, form of learner participation, form of changes (physical or non-physical), and motivational requirements.

Introduction

The advent of the computer has made possible a new and exciting form of learning environment, the simulation. We now have the technology for a powerful form of instruction that is both dynamic and interactive and that can provide considerable variety within a simulated environment. Even a personal tutor is incapable of such versatility. Computer-based simulations can provide efficient, effective, and highly motivational instruction that can readily serve the need for individualization. Simulations also enhance the transfer of learning by teaching complex tasks in an environment that approximates the real world setting in some important ways.

How effective a simulation is in doing this will be determined by three major aspects of its design: the scenario, the underlying model, and the instructional overlay. The **scenario** of a simulation recreates to a greater or lesser degree a real life situation. It determines what will happen and how it will take place, who the characters are and what objects are involved, as well as the learner's role and how he or she will interface with the simulation. To simulate a situation, the computer must respond to learner actions in a way that reflects that situation. This requires a **model**, usually a mathematical formula determined by an expert, which reflects the causal relationships that govern the situation. Finally, the simulation should have an **instructional overlay** to optimize learning and motivation.

This paper focuses on prescriptions for designing the instructional overlay, for our analysis of simulations has revealed that this is by far the weakest of the three aspects of simulation design in educational simulations that have been created to date. However, a brief comment about the other two aspects is in order.

The scenario and underlying model should reflect, to some degree, the situation being simulated. But to what degree? Should we always attempt to create maximum fidelity, or is it sometimes more effective to alter or simplify reality? Alessi (1987) suggests that maximum fidelity does not necessarily provide the most effective instruction. We propose that certain aspects of the real world situation should be represented with high fidelity in the simulation, while some need not, and some should not. We suspect that the "fundamentals" of the real situation should have high fidelity: those basics which determine the nature of the mental and in some cases physical activities required of the learner in the real situation. More superficial aspects of the real situation are less likely to improve transfer to the real situation when designed into a simulation and may in fact create overload, which impedes learning and motivation. We suggest that four factors should be considered in all decisions about fidelity of the scenario and model:

- Overload - the degree to which superficial details or complexities of the real situation obscure the content to be learned.
- Transfer - the ability to use what has been learned in the real situation(s).
- Affect - the motivational appeal of the simulation.
- Cost - design, development, and production cost of the simulation.

Overload and cost generally argue against fidelity for superficial aspects of the real situation, whereas transfer and affect generally argue for it. Often the best design is one which begins with low fidelity and progresses by levels to high fidelity at the end of the instruction.

The remainder of this paper addresses the third aspect of simulations, the instructional overlay, which includes all the instructional design features of a simulation and how they should be used to optimize instruction.

Instructional Overlay

Despite the existence of a considerable number and variety of simulations, a literature review for the instructional overlay, has revealed that few generalizable prescriptions have been offered to guide the design of instructional simulations. Most simulations have been produced using a "seat of the pants" approach. Some are quite good; many are nothing more than video-type games or drill-and-practice exercises. Almost none provide a complete instructional package. In our attempt to formulate an instructional model for the design of computer based simulations, we have addressed the following questions:

- What are the different kinds of simulations?
- When should each kind of simulation be used?
- What characteristics should each kind of simulation have to provide optimal instruction?

We have conducted a survey of the literature and analyzed a variety of simulations to provide answers to these questions.

The dynamic and interactive nature of computer-based simulations provides an ideal medium for teaching students content that involves changes. Such content includes what Merrill (1983) refers to as principles and procedures and Gagne (1985) refers to as rules, a subcategory of his intellectual skills. While simulations may also be used to teach facts and concepts, the nature of this type of simulation would be very different. Our theory has been developed only for simulations that teach principles and procedures.

In our analysis of simulations and literature about simulations, we have found that the the nature of the content or behavior being taught is the major influence on the features a simulation should have. For example, mastery of many procedures such as long division and writing a good paragraph, is gradually acquired over time. But for most principles, mastery is an instantaneous, all-or-nothing, flash of insight or understanding. Clearly, methods of instruction must be very different for each of these two kinds of learning, and the design of a simulation will need to be very different for each. In fact, we have identified three major types of simulations: those that teach procedures, those that teach process principles, and those that teach causal principles.

What we have defined as **procedural simulations** include both the physical and procedural categories described by Alessi and Trollip (1985). Procedural simulations teach the learner to perform a sequence of steps and/or decisions, as in flying an airplane or adding fractions. A **process simulation** teaches naturally occuring phenomena composed of a specific sequence of events. Unlike procedures, processes are not purposively performed by people, but are naturally occuring, as is the action of a volcano or the process of photosynthesis. A **causal simulation** teaches the cause-effect relationship between two or more changes, for example, the law of supply and demand and the theory of natural selection.

Possible Functions of Simulations

It is useful to think in terms of three phases in the learning process that should be activated by educational simulations, unless other media of instruction do so. The learner must first **acquire** a basic knowledge of the content or behavior. Then he or she must learn to **apply** this knowledge to the full range of relevant cases or situations. The final stage is an **assessment**, in some cases a self-assessment, of what the learner has learned. Therefore, the first set of instructional strategies in a general model for simulations should be concerned with **acquisition** of the content, the second set with **application** of the content, and the third with **assessment** of learning.

The first function, acquisition, is to teach the content, which in our case is either principles or procedures. For principles the learner must acquire a meaningful understanding of the natural processes or cause-effect relationships. For procedures the learner must acquire knowledge of what steps to follow and how and when to do each step.

After the learner has achieved acquisition, he or she must then learn to apply this knowledge. For both procedures and principles **generalization** is required. For example, the learner must develop the ability to apply the steps of a procedure to the full range of inputs and conditions that may exist. Mastering a procedure often requires **automatization** as well as generalization. The learner must develop the ability to perform the sequence of steps and/or decisions almost without thinking. This is generally achieved through repetitive practice. Application of causal principles requires **utilization** in addition to generalization. A performance routine that governs the application of the causal principle must be learned or invented by the learner. Utilization refers to the ability to use the appropriate performance routine in order to apply the principle.

The assessment function of the simulation determines if the learner has achieved mastery. Mastery is a specified criterion for the number of correct responses and/or speed of response on a set of divergent and difficult, previously unencountered, practice items.

It is not always necessary for all three of these instructional functions to be served by a simulation, for any one or two of these functions can be accomplished outside of the simulation. However, often no provision is made for a function to be accomplished if it is not specifically included in the simulation. And there is usually no valid reason for not including all three within the simulation.

Features of Simulations

Based on instructional theory and an examination of many simulations, we have identified five simulation features that act as vehicles for achieving acquisition, application, and assessment. These include the generality, example, practice, feedback, and help. These basic features of simulations correspond to the presentation forms of Merrill's (1983) Component Display Theory and four of Gagne's (1985) events of instruction (present the stimulus, elicit a response, provide feedback and provide learner guidance).

The **generality** is a statement of the relationship among changes that characterizes a procedure or principle. It may take the form of a verbal presentation, for example, a statement of the law of supply and demand, or it may be a visual representation, such as a set of graphs showing the relationship between supply and price and between demand and price.

An **example** is a specific instance or case that shows the relationship among changes described in the generality. It may be presented as a **demonstration** with no active learner participation or as an **exploration** in which the learner manipulates the example to see what happens. The nature of this type of learner participation is different from that required for application of the generality in that the learner's behavior is not that specified by the objective.

Practice provides the learner with the opportunity to apply a generality to diverse instances with the required proficiency. Practice consists of two components: a **stimulus** situation presented by the simulation and a learner **response** that is consistent with the instructional objectives.

Feedback provides the learner with confirmatory or corrective information regarding his or her responses. Allessi and Trollip (1985) note that there are two forms of feedback, natural and artificial. **Natural feedback** is a real-life consequence of a response; **artificial feedback** is a contrived consequence which would not occur in the real situation. In the "Flight Simulator", dials showing altitude and fuel level are forms of natural feedback, as well as the view through the cockpit window.

Natural feedback may be sufficient for simple tasks but may not provide enough information for complex tasks that require a chain of responses before the natural consequences manifest themselves. In such cases artificial feedback may be used to provide the learner with additional assistance and may be either **informational** or **motivational** in nature. A statement in a flight simulation that tells the learner to check his fuel gauge is informational feedback because it provides additional information that would not occur in the real situation. Phrases such as, "Keep up the good work!" or "Try again, you can do it!" provide praise or encouragement to the learner and so are motivational types of artificial feedback.

Help provides the learner with direction and assistance during the presentation of the generality, examples, practice and feedback. The difficulty of the content and the instructional approach (expository or discovery) will determine what type and how much help is needed. We have distinguished three different types of help based on function. The first **directs attention** using flashing, color, bold, arrows, labels, etc. to emphasize important aspects of the presentation. The second **relates the instance** (example or practice case) **to the generality** by providing commentary. The third type **facilitates encoding** by providing a second representation, for example a diagram, along with a definition. This tends to increase the depth of processing and enhance understanding and retention.

Another feature of simulations is the **representation form**, the way in which material is displayed on the screen. We have adapted Bruner's (1960) classification to characterize four representation forms: enactive, iconic, visual symbolic, and verbal symbolic. The **enactive** form uses a 3 dimensional unit along with the computer to provide the most realistic simulations. An **iconic** form, the second most realistic, consists of video or graphic displays. Less realistic but very effective for simplifying difficult content, **visual symbolic** uses symbols or icons, and **verbal symbolic** is composed of letters and numerals.

All four representation forms may be used to produce a dynamic presentation that requires learner participation, but the degree of realism will differ depending on the nature of the content and the instructional objectives. As was discussed above regarding the fidelity of the scenario, the simulation can often be most effective by simplifying to eliminate distracting and unimportant aspects of the real situation or by altering the speed of a process to reveal what is not normally evident. In other situations the closest approximation of reality may be desirable to enhance learning transfer.

Figure 1 presents a summary of the available features that can be used to achieve the functions of simulations. During acquisition, if the learner is not required to figure out the generality, an **expository** approach is being used and the learner should be presented with the generality and a prototypical example. Application with no performance of the criterion behavior is an **example**. When learner participation is utilized, the approach and features are different. In the case of acquisition, if an example is presented and the learner required to "figure out" the generality, a **discovery** approach is being used. Application that involves performance of the criterion behavior is **practice** and should be accompanied by feedback. It is important to note that the two types of examples, **observation** and **exploration**, also differ based on learner participation or lack thereof. Unlike an example that is purely observational, an exploration type example can be manipulated by the learner through the keyboard or some other input device. The general instructional model and variations that follow prescribe the optimum features and approach for each kind of simulation.

Insert Figure 1 about here

A General Model for Simulations

The theory we have constructed originates with the three phases of learning described above. We have organized and adapted the features of simulations to provide the learner with the most effective and efficient presentations in order to achieve successful acquisition, application and assessment. Our general model describes five aspects of simulations and provides prescriptions for the implementation of each. It applies to all simulations for teaching principles or procedures. Specific conditions or types of simulations require their own characteristic prescriptions that are described as variations on the general model.

Before proceeding with the "how to" of simulation design, some consideration should be given to the question of "when to" use simulations. We believe that simulations are an extremely efficient and effective form of instruction for content involving changes and therefore should be used to teach principles and procedures whenever the audience is large enough for computer-based simulations to be cost effective.

Select the Appropriate Complexity

The design of the instructional overlay for any simulation begins with selection of the appropriate complexity for the content or behavior that is to be learned. The real situation is usually quite complex, with many variables to consider for successful performance. To begin with so many variables in the underlying model will clearly impede learning and motivation. The best design is usually one which begins with only one or two variables in the model and progresses by levels to include all important variables at the end of the instruction. This is a matter of "instructional overlay" being superimposed on the model.

- First determine the complexity of the most realistic underlying model you will use.

- If it is comprised of only a few variables, select an integral approach; that is, do not break it down into simpler levels.
- Otherwise plan on simplifying the model using one of the approaches described under "Variations on the General Model" below.

Introduction

The simulation begins with an introduction that describes the scenario, identifies goals and objectives, and presents directions and rules that will govern the simulation.

- Set the stage in the **scenario** presentation by describing the setting, the form of learner participation, and the major characters or objects. Describe how the simulation will proceed, what will happen, and under what circumstances.
- Present the **goals and objectives** whenever possible as part of the scenario to provide a concrete example and to enhance meaningful understanding and motivational appeal.
- Use **directions and rules** to describe how to use the program, including such things as key functions, use of learner control, and other options. Present directions as text with graphic or video support that requires minimal dependence on documentation. Present rules as a demonstration within the scenario whenever possible.

Acquisition

During the acquisition stage the learner develops a meaningful understanding of a principle or knowledge of the steps in a procedure. The acquisition function may be achieved by means of an expository or a discovery approach and may require either exploration or observation by the learner. In an **expository** approach the generality is presented; in a **discovery** approach the learner is required to "figure-out" the generality. The preferred approach and form of learner participation depends on the nature of the content and criterion behavior and is discussed later under "Variations."

- If an expository approach is used, provide the generality along with a prototypical example for the learner to explore or observe (see "Variations"). The order of the generality and example may be varied to create either an inductive or deductive expository approach (see "Variations" below).

- For a discovery approach, require the learner to "figure-out" the generality by exploring or observing a prototypical example. Provide help in the form of hints and prompts to assist the learner with the discovery process.
- Provide help to direct attention, relate the generality to the example, or facilitate encoding by presenting a second representation as needed during acquisition. Use more help and use it more frequently depending on the difficulty of the content in relation to learner ability and experience.

Application

During the application stage the learner develops the ability to use the principles or procedures that have been introduced in the acquisition stage. The primary element of the application stage is divergent practice composed of a stimulus, a learner response, help, and feedback.

- Provide cases which have a variety of **stimulus** conditions that include the full range of divergence existing in the real world.
- It may be necessary to create a mechanism for randomly producing cases that include all possible varieties of stimulus conditions.
- Use an easy-to-hard progression of difficulty for presentation of cases.
- If different levels of difficulty are used, require the learner to reach criterion on one level before going on to the next level.
- Use a representation form as close as possible to that of the real world situation unless some form of simplification in terms of time span or complexity is helpful or required by cost considerations.
- Provide **pre-response help** (prompts and hints) when the difficulty of the task makes it necessary to direct attention or relate the practice item to the generality. This form of help should fade as practice progesses.
- Require a learner **response** consistent with the terminal objectives (criterion behavior) for the content.

An essential component of practice is the **feedback** which follows the learner response. The following prescriptions provide guidance for the design of effective feedback.

- Use natural feedback to maximize the reality of the simulation. The underlying model (discussed earlier) should produce the apropriate natural feedback for the responses given.

- For simulations that require greater frequency in the feedback schedule and/or greater information than is provided by natural feedback, use artificial feedback.
- Present artificial feedback with natural feedback at first and then gradually fade it as the learner masters the task.
- Provide help as needed (depending on the difficulty of the content) at first, then gradually fade it.

Assessment

After completing the instructional phases of the simulation, a **criterion test** must be administered to determine if the learner has mastered the content.

- Present new cases as test items and include the full range of difficulty and divergence. These cases should be interchangeable with practice cases.
- Use a scoring mechanism and establish a criterion score that must be achieved for mastery.
- Display the score as the learner progresses through the test unless such a running score interferes with the nature of the real-world task or provides prompting of some kind.
- A test may be done as part of the practice, provided the items are new, but a penalty should be registered for any help provided (both pre- and post-response help).
- If criterion is not met, immediately follow the test with a thorough debriefing. It should provide artificial feedback for all mistakes made.

Control

The issue of control influences all components of a simulation. The prescriptions that follow allow the learner to exercise control over some aspects of the simulation while maintaining system control over others. To some extent user or system control will be determined by the instructional objectives, but in general the following prescriptions apply to all simulations.

- System control of the **level of complexity,** including a provision for the teacher to input the appropriate entry level for each learner.
- System control of the **learner's progress** from one level to the next to ensure that mastery is achieved at each level before allowing the learner to go on to the next level.

- System control of **routine features** (generality, example, practice, feedback items) of the initial presentation for a new principle or procedure. Then permit the learner to choose to see additional cases in example form or to go back to a generality or example at any time during a practice case.
- System and learner control of **help.** Provide some help to all learners on early examples and practice, then fade. Permit the learner to select additional help on an optional basis.
- System control should require the learner to see the **introduction** the first time the simulation is used. From then on access to the introduction should be optional and under learner control.
- Provide the option for both system (including teacher input) and learner control of **test criterion** to provide maximum flexibility of use. Learner control may be implemented by allowing the learner to select a test of a particular difficulty level or to specify the number or percent of correct answers required. In some situations this becomes highly motivational in that the learner attempts to better his or her score, much like a game, each time he or she uses the simulation. In many cases the teacher may select the difficulty and criterion level for mastery by setting specific variables made available in a learner management section. This is especially useful for individualization of learner assessment.

Variations on the General Model

While it appears that all simulations should include the prescriptions described in the general model, there are certainly many aspects of a simulation that should vary from one situation to another, depending on such conditions as the nature of the behavior to be learned, the form of the changes that occur, and the motivational requirements. The following prescriptions for variations on the general model describe when to use each type of simulation and what it should be like.

Nature of the behavior

The nature of the behavior being simulated will determine the nature of the acquisition and application stages of the simulation, including the mode (expository/discovery) and form of manipulation (observation or exploration). Hence, type of behavior is the single most important basis for prescribing variations in a simulation.

There are three major variations of the general model based on the three types of content: procedures, process principles, and causal principles. Figure 2 presents prescriptions to guide the design of the acquisition and application stages for each.

Insert Figure 2 about here

As previously discussed, the generality can be presented using an expository or a discovery approach, both of which require the presentation of a prototypical example. The learner may be required to observe only, or to manipulate the example and then to observe the result. Acquisition may, therefore, be accomplished by a discovery or expository approach, either of which may present the prototypical example by observation or exploration. For the acquisition stage of **procedural** simulations:

- Use an expository approach because it is not feasible or useful for the learner to "figure out" the generality. This is best done by presenting the generality simultaneously with a prototypical example of the procedure.
- Require the learner to observe the example.

For acquisition of **process principles**:

- Use an expository approach because, as with procedures, it is neither efficient nor effective for the learner to engage in a trial-and-error search to discover the generality. This is usually best done by presenting the generality simultaneously with a prototypical example of the process.
- Require the learner to explore the example, if possible. Exploration requires that the learner turn the process on and off in the example and then observe the results.

Causal principles are quite different in nature from procedures and processes because not only must the principle be learned, but the routine needed to apply it must be learned as well. For acquisition of **causal principles**:

- Use a discovery approach. The change relationships should be clearly presented in a prototypical example, and with help, the learner can be lead to "figure out" the principle, resulting in enhanced understanding.
- Require exploration of the example by the learner.

After the learner has acquired the generality, the simulation should proceed with the application stage to teach the learner to apply the generality in any situation that might be encountered at the criterion level of performance. For application of **all three types of content**:

- If the task is fairly difficult to master, precede the practice (a component of the general model) with divergent examples of the procedure, process or causal principle.
- Use performance practice to provide the breadth of experience needed to achieve accuracy in applying the generality to divergent cases.
- The number of example and practice cases should depend on the difficulty of the task.

Procedures differ from principles in that automatization is usually necessary to ensure sufficient speed of performance and to reduce conscious cognitive processing requirements during performance. Therefore, in addition to the prescriptions above,

- Provide drill practice to a speed criterion after the accuracy criterion has been reached on performance practice.

For **causal principles**, application must teach the routine for utilizing the principle, as well as the application of the principle by utilizing the routine. Therefore,

- Require the learner to observe demonstrations of the routine as it is utilized to apply the principle.
- Use help to clarify and emphasize the steps in the routine.
- Then provide divergent examples and performance practice using the routine to apply the causal principle.

To design the example and practice cases, it is important to analyze the kinds of cognitive behaviors that are learned for each type of content. For a **procedure** the learner is expected to execute a sequence of steps and/or decisions to achieve a particular goal. For a **process principle** the learner is expected only to describe a sequence of naturally occuring events. For a **causal principle**, however, we have identified three different types of behaviors: prediction, explanation, and solution.

In terms of causes and effects, the **prediction** behavior is expected when the objective requires the learner to predict the likely effect(s), given a set of causes. A simulation that presents a variety of lens shapes and asks the learner to predict the effect of each on light rays requires prediction behavior. **Explanation** behavior is expected when the objective asks the learner to identify the likely cause(s), given an effect. An explanation simulation might require the learner to identify the causes of pollution in a lake, the physical traits of parents of a particular fruit fly or the reason for an increase in air pressure under specified conditions. **Solution** behavior is expected when the objective requires the learner to select and implement the necessary causes to bring about a desired effect (i.e., to engage in problem solving). "Lemonade" is a solution simulation that requires the learner to maximize his or her profits using knowledge of the law of supply and demand.

Hence, there are five types of behaviors: execution, description, prediction, explanation, and solution. Figure 3 prescribes the nature of the stimulus and response for the practice cases for each of the five types of behaviors. Often, the learning objectives for content composed of causal principles do not require a specific form of response but rather the general ability to use the principle in any form. If this is the case, use a variety of prediction, explanation, and solution simulations to provide the learner with greater divergence of behaviors. For complex content require prediction and explanation behavior for individual principles first, then solution behavior for integrated practice of a number of related principles.

Insert Figure 3 about here

Complexity of the Content

Before the actual design process begins, the complexity of the desired content and/or behavior must be analyzed to determine if it can be presented as an integral whole or if it must be broken down or simplified. This will determine the kind of macrolevel sequencing for the domain-specific content.

- If the content is relatively simple and involves a limited number of constructs (principles and procedures), teach it as an integral whole (Gropper, 1983; Landa, 1983).
- If the content is difficult, simplify it using an elaboration approach (Reigeluth & Stein, 1983).

If the content is procedural, the elaboration theory describes a methodology for simplifying the procedure until it is simple enough to learn as an integral whole (Reigeluth & Rodgers, 1980; Reigeluth & Rawson, in press). Then that "epitome" is gradually elaborated upon, one level at a time, until the complete procedure (as called for by the objectives) is mastered. Although the basics of that methodology also apply to solution tasks, some extensions of that methodology are useful. Space limitations make it impractical to include these prescriptions in this paper.

If the content is primarily principles, the elaboration theory describes a methodology for simplifing the task by requiring use of only the one or two most important and most broadly applicable principles for making the prediction, explanation, or solution (Reigeluth, 1987). Once that principle (or two) has been taught in an "epitome" simulation, more detailed and precise principles are then taught as "elaborations" until the complete domain of principles (as called for by the objectives) is mastered. Such simple-to-complex sequencing within a simulation is extremely important to the instructional quality of the simulation.

Learner Participation

The type of learner participation also varies depending on the nature of the content or behavior being simulated. We have therefore characterized the type of learner participation required for each of the three types of content described above: procedure, process principle, and causal principle. The learner role in the acquisition stage is different from that in the application stage. Alessi and Trollip (1985) have identified three types of learner behavior: observing, playing a role, and controlling.

Figure 4 summarizes the prescribed learner role for each type of content during the acquisition and application stages.

- For procedures require the learner to **observe** the simulated performance of the procedure and then to perform the procedure by **playing a role** during the application stage.
- For process principles require the learner to **observe** the naturally occuring events during acquisition and then to describe the sequence of events by **controling** the simulation (for example, placing the events in the appropriate sequence) during application. • For causal principles require the learner to manipulate (**control**) examples, **observe** causes or effects, and "figure out" the principle during acquisition. Then, for application, require the learner **to play a role** in which the principle is applied. For example, if the principle is the law of supply and demand, the role may be that of an economist predicting effects of changes in price or a businessman trying to maximize his or her profits.

Insert Figure 4 about here

In the case of procedures and causal principles the learner can practice in conditions similar to those of real life. He or she can actually perform the procedure or apply the principle under realistic conditions. Simulations are often the only means of instruction that can make this type of practice possible.

Form of Changes

Alessi and Trollip (1985) have categorized simulations on the basis of the physical or non-physical form of the changes being taught. A procedure is physical when physical movement is to be learned, as in a flight simulation. A principle is physical when physical changes are to be observed by the learner, as is the case in a simulation of volcanic action. All other procedures and principles are non-physical. The physical or non-physical nature of the behavior being simulated is the major factor in determining the representation form of choice. In general physical changes require greater realism of presentation than non-physical changes. The following prescriptions specify representation forms in order of preference for each simulation category.

- Physical procedure: enactive (3-dimensional simulation), iconic (video or graphics)
- Physical principles: iconic (for enhanced transfer and motivational appeal)
- Non-physical procedures: iconic (if possible), symbolic
- Non-physical principles: iconic (if possible), visual symbolic (diagrams, graphic art, graphs), verbal symbolic (text, numerals)

Motivational Requirements

If the anticipated attitude of the learners towards the task requires highly motivational instruction, a game-type simulation should be used. Some literature exists prescribing components of simulation games (Priestley, 1984; Carson, 1987). The specific prescriptions that follow provide a brief summary.

- **Establish rapport** between player and computer at the outset by providing the computer with a name, by using the player's name in computer responses and by using the first person in computer responses to the player.
- Present the **rules** of the game usually in the form of text accompanied by an example.
- Use a **non-zero based scoring system.** Maintain records of scores, timed responses, number of attempts (correct and incorrect), levels of difficulty attempted.
- Create a **competitive situation** in which the player wins by beating the computer, another player, or his or her own score.

- Provide **player control** over some aspects of the simulation, such as: number of players, entry level of difficulty, choice of opponent (may include computer or another player), response time, length of play.

Conclusion

We have provided some prescriptions for the design of computer-based simulations in the form of a general model and variations on the general model based on the nature of the task and learner. These prescriptions are just the first step in an attempt to construct a validated prescriptive theory for the design of computer-based simulations. Considerable research and extensive field tests are needed to provide the information necessary for both confirmation and revision of the various aspects of the theory. It is our hope that this theory will provide a useful framework for conceptualizing future research studies and that revisions and enhancements of the theory will be proposed from such research. Meanwhile, although caution should be exercised regarding the validity and optimality of the theory, it is our hope that it will serve as a useful guide to designers of computer-based simulations and that its usefulness will grow as the cycle of research and revision continues.

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	No participation	Participation
Acquisition	by expository approach: Generality with a Prototypical Example	by discovery approach: Prototypical Example to Figure Out the Generality
Application	without criterion performance: Examples	by criterion performance: Practice with Feedback
Example	without manipulation: Observation	by manipulation: Exploration

Figure 1. Feature-function map.

VARIATIONS ON THE GENERAL MODEL

	Acquisition	**Application**
Procedure	Expository by observation: Generality + Prototypical Example	Divergent Examples + Performance Practice (accuracy) + Drill Practice (speed)
Process Principle	Expository: Generality + Prototypical Example	Divergent Examples + Performance Practice (accuracy)
Causal Principle	Discovery (of principle) by exploration: Prototypical Example of the principle	Divergent Examples of the principle + Discovery (of routine) by observation (via Divergent Examples of the routine) + Divergent Performance Practice (accuracy)

Figure 2. Variations: Features for functions for each type of content.

KIND OF SIMULATION	ACQUISITION	APPLICATION
Procedure	Observe a role	Play a role
Process Principle	Observe	Control
Causal Principle	Control and Observe (for exploration)	Observe (routine) Play a role (practice)

Figure 4. Variations: Role of the Learner

Type of Simulation		Nature of Practice	
Behavior	**Example**	**Response**	**Stimulus**
Execution (Procedure)	Add fractions or Select math operation	Use a sequence of steps and decisions	Goal, inputs
Description (Processes)	Plant Life Cycle	Describe a sequence of effects	Situation
Prediction*	Predict effect of increased price	Predict the likely effects	Causes
Explanation*	Identify cause of increased demand	Identify the likely causes	Actual effects
Solution*	Maximize profits	Select and implement the necessary causes	Desired effect & inputs

*Cause-effect Principles

Figure 3. Prescriptions for the nature of the stimulus and response for practice cases in five types of simulations.

Title:

The Search for Meaningful Reform: A Third-Wave Educational System

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The Search for Meaningful Reform:
A Third-Wave Educational System

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I am deeply grateful to Ruth Curtis, Bonnie Keller, Bonnie Lang, Don Parks, and Joe Powell for their considerable input into the development of the ideas presented in this article.

Abstract

It is widely recognized that our educational system has some important shortcomings. This paper proposes that such "problems" as lack of teacher incentives, poor student motivation, lack of leadership, and lack of community support are in fact just effects of a more fundamental problem. Just as the one-room schoolhouse, which was so appropriate for an agricultural society, proved to be inadequate for an industrial society, so our present system is proving to be inadequate for an information society. It is the fundamental structure of our educational system that is at the heart of our current problems. For example, it is our group-based, lock-stepped, graded, and time-oriented system that has the dubious distinction of effectively destroying the inherent desire to learn in all but a small percent of our children. Furthermore, micro computers are accelerating the trend toward increased use of nonhuman resources in the education of our children, and the current structure of our educational system cannot adequately accomodate the effective use of these powerful educational tools. But what alternatives are there? Until recently there have not been any viable ones, but our pedagogical knowledge has now evolved to the point where there is a viable alternative to the present structure. This article describes a general approach and a specific strategy for effecting the sorely needed structural changes, and describes some initial progress on implementing that strategy. This initial progress is a preliminary "blueprint" outlining the structural characteristics that a "third-wave" educational system should have.

There is a growing lack of confidence in our present public school system. Time Magazine has said,

> Like some vast jury gradually and reluctantly arriving at a verdict, politicians, educators, and especially millions of parents have come to believe that the U.S. public schools are in parlous trouble.1

The Chronicle of Higher Education reports that educators and noneducators alike are calling for sweeping reforms of America's public schools.2

The recent National Commission on Excellence in Education was created because of "the widespread public perception that something is seriously remiss in our educational system."3 The Commission's report, entitled "A Nation at Risk: The Imperative for Educational Reform", cites Paul Copperman as drawing the conclusion that "for the first time in the history of our country, the educational skills of one generation will not surpass, will not equal, will not even approach, those of their parents."4 The Commission concluded that, "if an unfriendly foreign power had atempted to impose on America the mediocre educational performance that exists today, we might well have viewed it as an act of war."5 As Paul Berman has recently noted, "The debate is no longer over whether American education is in trouble, but over what should be done."6

What Is the Cause of Our Problems?

Before we can identify what should be done, we must identify the causes of the current problems with American education. The Commission cites poor content (we are teaching the wrong things), insufficient learning time (we are not teaching it long enough), poor quality of teaching (we are not teaching it well enough), low standards and expectations (we are not demanding enough from the students), and lack of leadership (we are not getting the kinds of initiative and direction that are needed from our administrators). But are these really the causes? Or are they symptoms of a more fundamental cause? Two things may be helpful to answer this question: (1) analyzing what goes on in a typical school and (2) looking at ways of improving systems in general.

Imagine you are a high school teacher. You want very much to excite your students about learning. How are you going to go about it? You have been handed a list of over a hundred students in four classes. You have a textbook that you are required to use and a year-end exam for which you need to prepare the students, so that all but a few minutes of classtime per week must be carefully scheduled in advance. On the first day of classes, twenty-five or thirty students will troop into your classroom at the ring of a bell and will troop back out 40 minutes or so later at the ring of another bell, regardless of whether the great moment of insight you have spent the entire class working up to is still two minutes away. The students will come into your class with very different levels of knowledge about your subject; most will not be very interested in it; and practically all will be hoping to be entertained more than educated. You don't really know anything about any of those students as individuals, so you are forced to focus your attention on the content and how you will deliver it to the "average" student in the class, rather than focusing on the individuals you are teaching and how you can address the needs and interests that each of them has.

Is a longer school day really the solution to your problems? Or better teacher training? Or higher expectations? Will such reforms help to sustain a love of teaching in the teacher or to instill a love of learning in the students? Milbrey McLaughlin and associates at Stanford University have noted:

> Many of the current reform efforts aimed at improving the quality of teachers fail to consider the configuration of conditions that leads even the most dedicated teachers to experience demoralization and a sense of personal failure. Indeed, some of the organizational and environmental features that contribute most prominently to this sense of failure are also basic aspects of the current system of education in the U.S.[7]

Similarly, Willis Hawley notes that "Motivating teachers without changing other conditions that affect teaching will not only limit the effect of incentives, but may cause frustration and alienation."[8] During my years as a high school teacher, I came to understand what many teachers have complained of: that the *structure* of the educational system is the root cause of most of the problems that beset our educational system.

What do we mean when we refer to the "structure" of our educational system? The structure is the basic organization of the teaching process. The major structural aspects of our present system include (1) *group learning*: having knowledge delivered to children in groups of 20 to 40 at a time, such that all children receive the same content at the same time and rate; (2) *constant rotation*: rotating the children from one teacher to another every 45 minutes or so; (3) *time-based grade levels*: requiring all children to "serve" the same amount of time before they are allowed -- or forced, as the case may be -- to progress to new levels of learning, regardless of when (or even if) they have mastered all the necessary knowledge and skills, (4) *isolation*: having all learning occur within the confines of the school walls and not encouraging (nor usually even allowing) parents or other segments of the community to participate and cooperate in the teaching process; and (5) *administrative organization*: having a single large school in a district, with administrators who are not also teachers and teachers who are relegated to a less influential and professional "staff" role within the educational system.

Of course there are other causes of our problems besides the structure of our educational system. Bad teachers do exist, lack of parental concern for their children does exist, and so forth. But there is increasing recognition that the *major* cause of the current problems with our educational system is the basic structure of that system. Theodore Sizer states:

> Can students learn how to learn to "study," when they are rushed from class to class over a seven-period day, where they are being taught by six or seven different teachers, no one of whom sees them more than five hours per week (and usually in groups of over 20 students), and when there is rarely any unequivocally reserved time for private study (homework, study halls)? Of course not. ... Until we honestly confront the inadequacy of school structure, we will continue to cheat students, frustrate teachers, and waste money.[9]

In *A Place Called School*, John Goodlad concludes:

> ... far-reaching restructuring of our schools and indeed our system of education probably is required for us to come even close to the educational ideals we so regularly espouse for this nation and all its people.[10]

Anne Westcott Dodd states:

> Band-Aid solutions proliferate: a longer school day and year, more required subjects, more homework, higher pay for teachers. But more of the same is not necessarily improvement. ... America can develop a whole new structure for public education ....[11]

Maurice Gibbons laments, "Ironically, when the old paradigm falls into disrepute, we do not make major changes; instead, we focus more intensely on those things we have always done ...."[12] Selma Wassermann talks about an alternative system

> in which each learner sets his or her own pace in working toward mastery of course material; ... in which teachers play diagnostic and facilitative roles, rather than controlling and judging ones; in which the initiative of the learners is cultivated rather than thwarted ....[13]

Harold Shane talks about "a growing need to redesign -- not merely to reform -- education in the U.S."[14] Ernest Boyer,[15] Seymour Sarason,[16] and Richard Brandt[17] all advocate some structural reforms, and the list goes on and on. As Paul Berman put it, "The conclusion is inescapable: American education, as it is now organized. has reached the limits of its effectiveness."[18]

Comparing Systems

Educational systems are like other kinds of systems in many ways. How are other kinds of systems improved? Our transportation system consisted primarily of the horse for a very long time. Like the one-room schoolhouse, the horse was very flexible for meeting the needs of the individual; you could go almost anywhere you wanted to. But there were problems with the horse. It wasn't very fast or very comfortable, especially in bad weather. Now, some people spent a lot of time trying to reform the prevailing structure by doing such things as breeding faster horses and building better roads and bridges to improve the horse's speed, or making more comfortable saddles and creating carriages for the horse to pull to improve comfort. But the gains to be made were small compared with the development of an alternative structure, the railroad.

The railroad was far faster, more comfortable, more reliable, and more efficient than the horse. It could transport many more people much greater distances far more cost-effectively. But, like our current educational system, it was much less flexible; you were greatly restricted as to where you could go and when.

As society has continued to change, our transportation needs have also changed. We must travel ever greater distances in less time, and people need to have much more flexibility as to when and where they will go. Many people have spent much time "fine-tuning" the railroad. But the "quantum leap" again came from an alternative structure, in this case one that entails the use of a variety of transportation media, primarily the airplane and the automobile.

As the one-room schoolhouse, a "first-wave" educational system, was appropriate for what Alvin Toffler calls a "first-wave" agrarian society,[19] so our present, second-wave, educational system has a structure and philosophy that were appropriate for a "second-wave" industrial society. Although there are problems with the industrial production model of schooling,[20] one cannot help but note some structural similarities to an assembly line, whereby students move from one specialist teacher to another at the ring of a bell to have a new component of education added to them. A "third-wave" system will provide a quantum leap for meeting the changing needs of our society, and like our current transportation system, it is likely that it will make use of a variety of means of learning, including peer tutoring, discussion groups, projects, and group activities of various kinds, in addition to well designed individualized resources and learning environments.21

Each structural change that has occurred in our transportation system has become possible only by the advance of technology, and in fact technological advances have made the rise of alternative structures inevitable. But the change is never revolutionary; it is evolutionary. Horses are still used for transportation in some places. Many trains are still in use today. And there are still many one-room schoolhouses. Structural reform is one of gradual replacement in places where the societal needs for change are strongest.

The process of structural reform in education will be a slow one for another reason as well. The more advanced our technology, the more room there is for improvements through fine tuning a structure. Look at how far the airplane has come since the Wright brothers' early days. How long was it between Kitty Hawk and the first trans-oceanic flight? How much longer until the first jet planes?

Although the change may be slow and gradual, it will also be sure. We can already see technological developments of the "Information Age" that are making structural reform inevitable. Since the invention of the printing press, there has been a gradual but steady increase in the use of nonhuman resources in the classroom, including textbooks, workbooks, handouts, and audio-visual materials of various kinds. Now, it seems that micro computers, because of their interactive capabilities, are greatly accelerating this trend. We are already reaching the point where the current structure of our educational system can no longer adequately accomodate the effective use of such resources. As more and better resources become available to relieve teachers of some of their more routine, boring tasks, we are likely to find even greater internal pressure for schools to adopt an alternative structure.

As we enter deeper into a "third-wave," highly technological, rapidly changing, information-oriented society, the present structure of our educational system will become more and more inadequate, both from the society's point of view and from the school's point of view, not to mention the child's point of view. According to Naisbit, an information society requires a different kind of person, one who is more of an analyzer, evaluator, problem solver and creative thinker, one who has more initiative, more love of learning, and more responsibility for his or her learning and decision-making.22 A third-wave educational system will provide a quantum leap in producing this kind of person.

In her excellent analysis of school reform reports, Patricia Cross23 compares the kinds of structural reform needed in schools with the kinds of structural changes taking place in businesses as outlined by Peters and Waterman in their best-selling book, In Search of Excellence.24 She concludes that

> In the long run, would-be reformers may be doing more harm than good, if they transmit the message that state officials can legislate and regulate educational excellence without paying attention to the task of creating climates of excellence at the local level. ... I have concluded that our commitment to the lock-step, time-defined structures of education stands in the way of lasting progress. It is simply unrealistic to think that all students can learn from the same materials, to the same standards

of performance, in the same amounts of time, taught by the same methods.[25]

In sum, as we advance into the information age, our highly regimented, graded, lock-stepped, group-based, and time-oriented rather than achievement-oriented system is less and less able to meet the needs of the individual, the society, and the school itself. Changing the curriculum, lengthening the school day, and legislating higher standards are band-aid approaches to fixing a broken leg; and they are likely to do as much harm as good in the long run.

In reference to the problems cited by the Commission's report, it is the structure of our educational system that renders the selection of content relatively insensitive to teachers and parents -- the two groups that perhaps should, as a team, have the strongest voice (with information and advice provided to them by "curriculum experts" and other concerned people). It is the structure of our educational system that leads to the establishment of "minimum standards" and expectations that are usually tailored to the least capable students in a class. It is the structure of the system that results in a very small proportion of the time in school being spent on actively learning. It is also the structure of the educational system that works against quality teaching by making it harder to teach well and by diminishing the rewards and incentives for quality teaching. Similarly, the structure of our system does not reward the kinds of leadership that are needed, and in fact it often rewards (or at least promotes) good bureaucrats and public relations people instead of good educational leaders.

But if this is true, how do we know that an alternative is feasible now? First, it is certain that an alternative will never be feasible if we don't work to develop it. If current feasibility were a necessary condition, the Wright brothers would never have gotten off the ground. But we are well beyond Kitty Hawk in the development of a "third-wave" educational system. The alternatives to a group-based, lock-stepped, time-oriented, graded system require the availability of well-designed learning resources and environments that are at once highly effective and highly motivating. Information technologies make it possible to create far better learning resources and environments than has ever been possible before, and those technologies are reaching a level of power and affordability that make them cost-effectively competitive for many educational tasks.

But "hard" technology (equipment) is only half the story. We haven't known enough about how to design effective and appealing learning resources and environments to make alternative structures for education feasible. Finally, that situation is changing and has in fact already changed enough so that a third-wave educational system is feasible.[26] The important question then becomes, "What would be a workable approach for determining the best structure and for implementing that structure?"

An Approach for Improving Public Education

Many problem solvers in business, industry, and education feel that initial efforts should entail thinking in the ideal, forgetting temporarily about constraints, and later compromising as necessary to implement a workable plan. When working with professors to help them to improve their courses, Syracuse University's Center for Instructional Development has found that many solutions that are initially thought of as unworkable under current constraints, are in fact workable, and that much better results are achieved by initially thinking in the ideal. In the ultimate analysis, this usually proves to be the most practical of all approaches.

Another important concern with respect to an approach for improving public education is that anything beyond fine-tuning of any system requires system-wide planning and modification. Any system that has evolved over as many decades as has our public education system has certainly developed many interdependent parts; and a basic tennet of systems theory is that, if you try to significantly change one part, the system will almost always work to change it back again. In fact, except in cases where gradual but sustained changes in the environment have caused gradual changes in a system, important changes in systems have not been gradual, piecemeal developments; rather each has taken the form of a "quantum leap", followed by gradual fine-tuning.27 Therefore, if we want significant improvement in public education, gradual, piecemeal modifications of the structure of the present system will not achieve the desired result. We need to develop an alternative system with a comprehensively different structure -- a quantum leap. The alternative system would then slowly and gradually be adopted by school districts across the country -- perhaps often as a single alternative school within a district -- as it became evident that the new structure would be better for that community's needs.

The following is an outline of a strategy for facilitating this gradual transition to a third-wave educational system.

A Strategy for Significant Educational Improvement

The airplane represents a quantum leap over the railroad in long-distance transportation. And just as a better long-distance transportation system (the airplane) was planned, developed, and gradually implemented and improved over a significant period of time, so also a better educational system can be planned, developed, and gradually introduced and improved over a significant period of time. In fact, any attempt to achieve widespread adoption of any significant innovation within a short period of time (such as occurred with Dewey's progressivism) is virtually doomed to crash, if it ever gets off the ground. The necessary training and coordination simply cannot occur effectively in such a short period of time, and the ideas and techniques inevitably become perverted and ineffective. Hence, the following strategy is offered:

Phase 1. Develop a comprehensive blueprint for an "ideal" third-wave educational system, with considerable input from educational analysts, practitioners, reformers, parents, and students. To the extent that it is cost-effective, conduct research and field tests on parts of the system to improve (replace, modify, or supplement) them as much as possible before implementation of the first prototype.

Phase 2. Secure funding from private and government sources to implement a prototype.

Phase 3. Identify the community for implementing the first prototype, perhaps a new community that will be starting up a public school system, or perhaps a large city district in which the new system would function as an "alternative school" within the current system.

Phase 4. Select or develop necessary instructional resources (described later), train personnel, build or remodel facilities in the selected community, etc.

Phase 5. Open the prototype school and constantly monitor and revise the various aspects of the system until it operates effectively and smoothly.

Phase 6. Build an Institute to publicize results of the system, facilitate its adoption by interested school districts, train personnel (and train schools of education to train personnel), accredit schools (but this accreditation would supplement rather than replace state accreditation), monitor and disaccredit schools, develop additional educational resources, and so forth.

Adoption would be a local-school-district decision, and there would be severe limits on the number of new systems that could be implemented each year, because of the training and "retooling" requirements that could realistically be handled by the Institute. Within 10 years of the implementation of the prototype school, it is likely that fewer than five per cent of the nation's public school districts would have changed to the new structure. The limitation is not so much one of expense, for we do not anticipate that teacher training would be any more expensive than it is at present, nor would the buildings and resources be any more expensive. Rather the limitation is one of expertise. It will take time for schools of education to learn how to train the new type of teachers. Hence, the new system will be equally affordable for rich and poor districts alike. In fact, it seems plausible that the districts which are having the most trouble will be the first to want to adopt the new structure (especially if outside funds accompany it for the first year or two), thereby providing a significant means for redressing current inequality of educational opportunity.

We propose that this is a workable and not particularly expensive strategy for implementing a significant improvement in public education.

INITIAL PROGRESS ON A BLUEPRINT

The remainder of this paper reports on some preliminary efforts to develop a blueprint for the third-wave educational system (Phase 1 above). We organized a small team of theorists and practitioners, parents and teachers, to work for four months on the initial development of the blueprint. We decided to focus our attention on the structural aspects of an educational system, both because there is so much evidence that the current problems lie primarily in the structure of the system and because we feel that the people of a community should decide on the goals and content of their children's education.

Foundations

Many people look back to the one-room schoolhouse with a good deal of longing and nostalgia. As with most things from the "good olde days," the one-room schoolhouse was not everything that we, our parents, or our grandparents remember it as being. There were, however, several educational advantages that the one-room schoolhouse had over our present schools. The teacher worked individually with most students, in contrast to our present group-based system. Students progressed at their own pace, as opposed to our current lock-stepped or tracked system. Students were not promoted to learn new skills and knowledge until they had mastered the current ones (nor were they held back once they had already mastered the current ones), in contrast to our present time-oriented, graded system. The teacher was responsible for the child (as opposed to a content area), was concerned with the whole child (as opposed to just one aspect of his or her intellectual development), and was often a partner with the child's parents and thereby responsive to their desires and able to draw on their influence.

Also, there were considerable benefits from having children of a variety of different ages in the same room, such as opportunities for peer tutoring and role modelling. A teacher was able to work with each child over a period of years and, therefore, a thorough knowledge of each child and a consistency in monitoring and follow-through existed that is often lacking in today's schools. In the present, second-wave school system, where children usually rotate from one teacher to another each day and completely change teachers each year, the teachers often just begin to know and understand most of the children by the end of the school year. This results in many needs going unmet and in a great deal of inefficiency in meeting those that are eventually met. And perhaps most important, the reduced knowledge and understanding of each child usually results in a great deal less caring than existed in the one-room schoolhouse. The negative effects of this problem have been made even more severe by today's large and impersonal school environments, which have done much to foment alienation and violence in our youth.28

We do not in any way believe that a third-wave educational system should merely be a one-room schoolhouse with modern paint. Times and needs have changed too much for that. But we do believe that we should carefully consider the positive and negative structural characteristics of our present and past systems in attempting to develop a structure that will be "ideal" for a third-wave educational system.

Overview

In our third-wave educational system, the teacher's role has changed from one of disseminating knowledge to one of motivating, advising, and managing the child's learning. Well designed resources (including interactive computer and videodisc systems), peer tutors, projects, and learning labs are used to convey most skills and knowledge. A teacher is responsible for a child for a period of three to five years. And the school district contains a variety of small, competing "schools" for parents to choose from (all at no cost to parents, and with no power for any school to turn any child away, thereby providing a degree of diversity and simultaneously a degree of accountability that are both sorely lacking in the present system). These and other aspects of the structure of an "ideal" educational system are described next. However, it is important to keep in mind that this blueprint is not likely to be a solution to all our nation's educational problems. We hope it will help to encourage new ideas and to further developments in the design of a better school system.

Teachers as Guides

Most people who have advocated structural reform of our schools have called for a different role for teachers, a role that is more professional and that relies more on technology to free the teacher from routine tasks and drudgery. Accordingly, in the third-wave educational system, the relationship between the teacher and the child is not one of purveyor and receiver of information. First of all, not all learning occurs in schools; the parents and the community are important sources of learning. Therefore, one of the teacher's roles is to orchestrate and coordinate efforts by parents, community, and school. Second of all, within the school, most knowledge is conveyed through well designed resources (including objects, printed materials, and interactive computer-based instruction), inexpensive assistants (including apprentice teachers, senior citizen volunteers, parents, and peer tutors), projects, discussion groups, learning labs, resource people, and so forth.

Hence, the teacher is more a guide than a teacher, as is the case in the Montessori system, which has functioned extremely well in this mode. The role of the guide is one of motivating, advising, and managing the child, rather than delivering most of the content knowledge. The guide is a conductor rather than a musician. She or he is an instructional manager who helps the child and parents decide upon appropriate instructional goals (within limits) and then helps identify and coordinate the best means for the child to achieve those goals. And those goals go beyond the intellectual development of the child; they may extend to the child's physical, social, moral and psychological development, depending on the parents' wishes.

Guides work individually and in small groups with children to insure that they reach their goals. Therefore, there is no such thing as a "class" in the sense of a group of children who learn the same material in the same place at the same time for a whole term or academic year. (There are, however, occasional discussion groups and seminars, which are especially useful in such areas as literature; and some mini-courses utilize class meetings when better alternatives are not available.) Each child has individual educational goals and could be matched to a unique combination of resources with the help of a computer-based advisement and management system. The cost-effectiveness of this system is very promising and is discussed later.

Developmental Levels as "Grade Levels"

In the third-wave school system a guide is responsible for each of his or her students for one of the developmental stages of the child's life: a period of approximately 3 to 5 years. On the basis of work by Piaget, Erikson, and others, we currently conceive of four stages as being relevant to the school system: approximately ages 3 to 5, 6 to 9, 10 to 13, and 14 to 18. The school organization is structured around these four levels, enabling each guide to work with a child for an average of four years. Either the parents or the guide can request a change before the child has entered the next developmental level, but there is a "test period" of, say, 6 months during which no changes are allowed. The process whereby parents request a guide is described next.

Parents Choose Guides

Parents request a guide for each of their children. On the basis of information made available by an independent "consumer reports" type of district office and on the basis of word of mouth and interviews with guides, the parents request in order of preference about three to five guides (depending on the size of the school district). The "consumer aid" office also provides diagnostic testing and interviews to help parents make the best decision, or to make it for them if they are not interested. Each guide decides how many children to accept each year, but does not decide which children to accept -- that is decided by a formula that maximizes the number of first choices filled district-wide.

"Clusters" as Independent Schools

In other professions like medicine and law, professionals often work together rather than independently; and, unlike teachers, they maintain a high degree of decision-making participation in, and control over, the organization. In a similar way, even though parents choose an individual guide, that guide does not work independently, but is a member of a "cluster" of guides. A *cluster* usually consists of about 3 to 6 guides, their assistants, their students, and a leader, who is a "master guide".

Like a lawyer in a law firm, each guide has considerable responsibility for the success of the cluster, *and* considerable incentive to meet that responsibility (see next paragraph), *and* considerable power to meet that responsibility. In the present system, teachers are given the first but not the last two! Is it any wonder that the structure works against good results! Just as the "administrator" of a law firm is a practicing lawyer, so the *master guide* is an active teacher. But the master guide also has a variety of other responsibilities, foremost of which is instructional leadership for the cluster. Ultimately, the master guide has the major responsibility for the success of the cluster.

Incentives and Rewards

The cluster's success depends on how satisfied the parents and children are, because its income depends in part on the number of first, second, and third choice requests for all of its guides. But it is the income of each cluster that depends on demand for its guides, not the income of each guide directly. A guide's salary is based only on the number of students he or she has and the cluster's gross income. Hence, there is considerable incentive to help any guides in the cluster who are not doing well. This results in a nice combination of competition between clusters (providing incentive for excellence and responsiveness to the community's diverse desires and needs) and cooperation within each cluster (providing support and encouragement among guides), not unlike that characterizing most other professions.

With respect to competition. the dependence of cluster income on parental satisfaction makes guides very accountable for what they do or don't do. If a cluster is doing a bad job of meeting parents' expectations, its income will fall, as will the income for all of its guides. With respect to cooperation within each cluster, the fact that a guide's income depends not only on his or her own efforts, but also on the success of the other guides in the cluster results in a much greater incentive to cooperate and help each other to insure that all the cluster's children do as well as they can.

Learning Labs

In the fields of law, accounting, and medicine, the general practitioner has access to specialists in different areas. In a similar way, the guide has access to various learning labs. A learning lab provides instruction in a specific subject area. It can be a traditional, discipline-oriented area such as biology or a cross-disciplinary, problem-oriented area such as pollution. These learning labs operate completely independently of the clusters.

All children in the school district receive a certain number of tickets or passes that entitle them to use the learning labs. The labs in turn receive their budgets on the basis of the number of passes that they collect, so there is considerable incentive to attract students and satisfy cluster guides' needs. Again there is a nice combination of competition between labs and cooperation within a lab. We currently envision three types of learning labs: "shopping mall" labs, site labs, and mobile labs. They are described in some detail later.

In summary, the major aspects we currently envision for the third-wave educational system are the following:

1. Teachers are guides who, in cooperation with the child's parents, motivate, advise, and manage a child's education for 3 to 5 years.
2. Resources (including well-designed materials, peer tutors, projects, discussion groups, learning labs, and resource people) are used to effect most of the learning.
3. There are no traditional "classes", but each child has individual goals, and a unique combination of resources and approaches is prescribed to reach those goals.
4. Guides work cooperatively within an educational cluster with

about 2 to 5 other guides, including a master guide.

5. The master guide sets the school climate and philosophy, hires guides and assistants, provides professional development for guides and assistants, and provides direction and leadership for the whole cluster.
6. After a trial period, parents are free to request to move their child to another available guide and cluster if they are not satisfied with their child's progress. Hence, individual guides and clusters are very accountable for what they do or don't do, and they have considerable incentive to work with parents.
7. Guides have a great financial incentive to cooperate and work together for the success of the whole cluster.
8. Guides can send children to learning labs of various kinds to receive the best available instruction on selected subjects.

The following is a more detailed description of the various aspects of the structure of this third-wave educational system.

Cluster Operations

Since the guide is the hub of this educational universe, we shall further describe the structure of the system on that level. As was mentioned above, every guide must belong to a cluster, which is much like a small law firm or medical clinic. Also, a guide is responsible for children for one complete level of development (approximately four years). In an exceptional case, a guide might prefer that his or her students be spread out over two or even three levels rather than just one. In such cases it is probably advisable that children switch to a different guide upon transitioning to the next level.

Each guide often uses apprentices (training to become guides), advanced students, and volunteers (including parents, senior citizens, and other members of the community) as assistants to help teach his or her students. Many receive credits for their services rather than money. Those credits entitle them to personal use of the learning labs for continuing education or the child care center for care of their own children. Tutoring is also a valuable experience for students. There is an apt addage that goes, "The best way to learn something is to teach it," and indeed I feel that I learned more about Economics in one year of teaching it in high school than in three years of majoring in it in college. Students are a very much overlooked resource that can save a school system much money, improve learning, and result in even greater benefits for the tutors. But they must have proper training and guidance to be most effective.29

At this point, our best guess is that in Level 1 (ages 3 to 5) each guide is responsible for about 25 children, in Level 2 (ages 6 to 9) about 35 children, in Level 3 (ages 10 to 13) about 45 children, and in Level 4 (ages 14 to 18) about 55 children. These differentials reflect the increased use of learning labs as the age level increases. Also, keep in mind that the services of apprentices, advanced students and volunteers considerably lightens the load of each guide. However, we must caution that these figures are our best guess at present, and experience may reveal better figures.

Also, as mentioned earlier, each guide decides how many children to accept; that is, what portion of a "full load" to accept. The importance of parent satisfaction keeps this figure from becoming too large, and the guide's personal income needs keep it from being too small. But if a guide wants to work half time on, say, writing a book or computer program, then he or she can do so by accepting fewer students (and receiving a lower income).

Anywhere from about 3 to 6 guides can comprise a cluster. With 4 guides in each cluster, there would be one guide on each of the four developmental levels, assuming that the cluster elects to serve all four levels. Such a cluster would have about 160 children spread out over the ages of 3 to 18. This means that there would be an average of about 10 children of any given age within the cluster. If the cluster serves only two developmental levels, there would be an average of about 20 children of any given age within the cluster. This size allows the children to get to know most other students in the cluster fairly well, resulting in a more friendly and caring environment and more cross-age interaction.

Specifics by Level

In Level 1 the guides are very similar to Montessori teachers.30 They introduce children to well-designed educational resources as the children become ready for them, and the resources do most of the teaching of knowledge and skills. The guides also arrange activities that help develop the child socially, emotionally, and physically (motor coordination). Children are exposed to a variable environment in which caring guides and assistants nurture their development and encourage them to alternate regularly between learning activity and social interaction, free play, exercise, and/or rest.

Most learning at this level takes place within appropriate cluster facilities, but field trips are occasionally taken so that the outside environment can influence the children's development. Mobile labs (discussed in the next section) and other outsiders (including parents) occasionally come and put on a program to enrich home-room activities.

Parents can leave their child in the cluster facility as long as they wish, but there is a charge if the child is left for more than six hours per day. This charge can be paid in money or in time contributed to the cluster. The more advanced children occasionally participate in activities in a Level II group. This facilitates their transition into the next level with a minimum of anxiety (even if the child advances to a different cluster). The timing of the full "graduation" to the next level is made in consultation with the parents and is based on a combination of the child's intellectual, social, and emotional development, including level of learning skills and degree of self-directedness and responsibility.

In Level 4, the opposite end of the developmental spectrum, the cluster facility is more of a conference room than a home room and activity room. Almost all content learning occurs in the learning labs, including lab-sponsored seminars, projects, tutoring sessions, and so forth. Also, intellectual scavenger hunts entailing interdisciplinary problem solving are widely used. Guides spend much time monitoring and motivating the children and just plain caring. Much time is also spent in individual conversations, for the guide is more a counsellor (an educator in the true sense of the word) than a teacher. In the domain of cognitive development, those conversations are often directed at higher levels of knowledge, including synthesis and evaluation in Bloom's taxonomy31 and cognitive strategies (or generic skills) in Gagne's taxonomy.32 Service projects are often required of students.

The guide also works closely with the parents on such other concerns as the child's emotional, social, artistic, moral, and psychological development. This entails (1) identifying with the parents any aspects of development that need work or any obstacles to further development that need to be removed, and (2) developing an appropriate plan that entails certain parental actions as well as certain guide actions of which the parents approve. As parents who have occasionally felt as if we were at our rope's end with one of our children, we feel it should also entail providing advice -- when desired by the parents -- on how to handle behavior problems and how in general to increase the quality of home life.

On the intervening levels (II and III), the guides serve both roles described above (for Levels I and IV). The degree to which each role is played by the guide progresses as the child develops from a Level I person to a Level IV person.

At whatever level, each guide must abide by a "renaissance approach" that establishes certain minimum levels of development in each of a broad range of basic areas (including basic skills). I have wonderful memories of a summer camp in which we campers were allowed to go to whatever activity we wanted whenever we wanted. There was a big chart on which achievements in each activity were posted for each camper, and we had to progress by at least one level of achievement in each activity every week. That way, when we went to do an activity that we didn't particularly like, we decided when to do it and we were motivated to get it done. And of course we all tended to far exceed the one-level minimum in activities that we liked. Also there were points given for each achievement, and campers were members of teams that competed to get the highest number of team points.

Similarly, in our "ideal" educational system, as long as the minimum levels of achievement are met in all areas, the children can study whatever they want whenever they want. As might be expected, the yearly and quarterly minimum levels vary depending on the general ability level of the child. For example, a child with an IQ of 50 is not expected to achieve the same minimum levels as one with an IQ of 150. Benjamin Bloom has evidence to suggest that the differences in rate of learning that currently exist in our schools are more a function of differences in accumulated skill and knowledge deficiencies than of differences in "intelligence" per se.33 The emphasis is on each child achieving according to his or her potential. For "late bloomers" the minimum levels are adjusted to represent relatively larger steps.

The guide maintains an achievement profile on each of his or her students on a computer-based advisement and management system. Grades are not given, because in an information society, a profile of the kinds of abilities and knowledge one has is more important than a letter grade or a general rank in class.

There are cluster-wide and district-wide interest groups and clubs, dealing with such interests as computers, drama, photography, woodworking, music, chess, dance, etc. There are also cluster-wide and district-wide social events and athletic events. A major benefit of this structure is a much higher rate of student participation in athletics and other interests. Opportunities for leadership and exercise of responsibility are also increased.34 Volunteers (parents, senior citizens, and other community members) and older students do much of the supervision, much as is presently done with Little League baseball and Scout programs.

Learning Labs

It was mentioned earlier that learning labs provide specialized expertise on different subject areas; and we have recently seen that the older the child, the more the labs are used. A learning lab can be for a traditional, discipline-oriented area such as biology or for a cross-disciplinary, problem-oriented area such as pollution; and it can be for an intellectual area such as philosophy or for a technical area such as automobile maintenance and repair. In all cases, labs would be encouraged to incorporate instruction in thinking skills and other higher-order skills into the content area instruction, and guides would be responsible for helping the student to put together a program of study that represents a good progression of such higher-order skills instruction. Resources are allocated to the labs on the basis of their usage, providing a combination of cooperation and competition similar to that for the clusters.

We mentioned earlier that there are three types of learning labs: mobile labs, "shopping mall" labs, and site labs. The mobile labs are labs on wheels that travel around from one cluster to another and even from one district to another. The shopping mall labs are centrally located labs to which the children in a district go. They range from a one-room, one-person (part-time) "craft shop" operation to a nation-wide operation (the Sears of the shopping mall labs). There tends to be continuous (although not too frequent) turnover as the "offerings" adjust to changing times and changing demands. Also, there are cooperative arrangements whereby children may use labs located in another school district. The site labs are located at the part-time organizations which sponsor them, such as museums and businesses. Tax write-offs are an important incentive for the creation of such labs.

All learning labs must be approved and periodically recertified by the school district's Lab Management Organization (described later). Learning labs can be started by almost anyone in any subject area, including cross-disciplinary areas, but certain training and standards (especially regarding character) are required. A learning lab director runs the lab; and depending on the nature of the lab, the director finds out about and makes available top-quality resources, plans good activities, makes arrangements for community-based experiences, hires, trains and monitors assistants (apprentices, advanced students, parents, and other members of the community) to help teach, and/or interacts personally with children to motivate, advise, and manage their learning within that specialty area. Teachers refer their students to specific learning labs and even to specific personnel in a learning lab. Many learning labs are run by part-time amateur/hobbyists and retired people at very little expense to the school district.

Logistically, the shopping mall labs would likely be located at the "hub of a wheel" in which the clusters are located in separate buildings out on the "rim," attached by enclosed walkways ("spokes"). This arrangement would eliminate the need for transportation and would allow for district facilities such as library, auditorium, child-care facilities, and food services to be easily accessible to all clusters, while still maintaining some physical separateness for each cluster. (Although food preparation could be done centrally, each cluster should have its own cafeteria to help build cluster cohesion.) Very large districts might have several such "wheels" at different locations within the district. Although such a logistical arrangement might be ideal, existing school buildings could be utilized with relatively few modifications to meet the same needs.

How the Student Uses the Learning Labs

At the beginning of each quarter (three month period), each student in the district is awarded a certain number of learning lab passes. The exact number depends on the child's level of intellectual development -- the higher the development, the more passes awarded. Also, each child can earn additional passes through such activities as tutoring, helping with the preparation of displays and materials, supervising extra-curricular activities, etc.

Some of the passes are "restricted" passes and some are "open" passes. The restricted passes must be used for the study of skills and knowledge specified by the child's "quarterly contract" (see below), whereas the open passes can be used to study anything. This results in a combination of structure and flexibility similar to that of the summer camp described earlier.

Each pass must be filled out and signed by the guide, who indicates the lab in which it is to be used. This helps the guide to influence and keep track of the child's learning. The child hands in the pass to the lab, so that the lab can then cash it in for payment from the discrict office. The passes could be implemented electronically with magnetic ID cards and electronic time clocks that feed data on student and lab usage into the district-wide, computer-based, advisement and management system. Teacher approval would be entered into the computer system, and the system would reject any child who tried to log in to a lab without such approval. Each lab allows each student a minimum of one hour of free "browsing" every quarter for purposes of seeing if there is anything he or she would like to learn in that lab. Of course, the lab receives remuneration from the school district for such browsing.

Having a limited supply of passes to use in a quarter, the children are more concerned with making the most of each one -- that is, not wasting precious time "hacking around." And having the flexibility to study what they want when they want (within the structure of the minimum requirements and the other goals specified in each child's quarterly contract) provides heightened motivation and increased self-determination and self-management that are so important in an information society.

What the Student Does

At the beginning of each quarter, the guide sits down with each of his or her students and the student's parents, if possible. Together, they prepare a plan or contract for the child's learning goals and activities for the quarter. As a result of this plan, a checklist of required goals and activities is prepared (probably with the help of the computer-based advisement and management system), and the use of restricted passes is planned. However, the plan is devised in such a way as to leave some time for children to pursue their own interests with their open passes, whose use is also discussed and informally planned at the beginning of each quarter.

The intent here is to establish a balance between structure and flexibility. Each cluster may establish its own policy (or lack thereof) with respect to the balance between requirements and options, except that the district may establish certain minimum levels of development in different areas for different age groups (perhaps adjusted by individual limits to rate of development as measured by, say, IQ or some better indicator).

At this time, the guide and parents may also have a private conversation about any problems the parents are having with the child so that the guide can give advice and/or take steps to help out. The guide also identifies things the parents can do or need to do to help the child achieve his or her quarterly goals (not just intellectual, but also emotional, social, artistic, physical, etc.).

At the end of each quarter, the guide sits down with each child and the parents (although two separate meetings would not be uncommon) and reviews the child's achievements in relation to the contract for the quarter. This provides part of the basis for planning the next quarterly contract, which usually occurs at the same session.

Extensions of the Present System

The present educational system would be extended in two important ways, in addition to the concern for non-academic aspects of the child's development: (1) it is open longer and (2) it is open for use by adults. It is open longer in three ways. It is open more hours per day, until, say, 9:00 p.m. This is done at very little extra expense because it is largely supervised by volunteer help. It is open on weekends, again at little extra expense due to volunteer help. And it is open all summer long.

Students can take vacations whenever their parents want, due to the individualized structure of the school. Similarly, guides and staff can take their vacations pretty much whenever they want because of the multiple-leveled staffing structure of the system (apprentice guides, volunteers, and older students). Guides feel less of a need for a long vacation in their new roles, and this eliminates the need for teachers to find summer employment at what are often not very rewarding (professionally or financially) jobs. Hence, it makes education a year-round profession, like law and medicine, with flexible opportunities for vactations.

Adults (people over 18 years old) can buy or earn passes to use the learning labs, making the school system a place where young and old can learn together. It also provides an extra source of income and labor for running the school system.

District Organization and Administrative Systems

All school tax revenues, block grants, and state aid go directly to the school district office for district-wide distribution. The district office establishes a budget for clusters (probably by establishing an amount per pupil and multiplying by the number of pupils anticipated for that year) and a budget for the Learning Lab Management Organization (probably by establishing an amount per pass and multiplying by the number of passes anticipated for that year). The budget for clusters is allocated to each cluster in accordance with the demand for its guides. The budget for the Learning Lab Management Organization is allocated to each lab in accordance with the number of passes it receives, except that a certain per cent is kept to meet its administrative expenses. Finally, the Consumer Aid Agency receives a flat per centage of the total school district budget (around one-half of one percent), and the district office keeps a flat per centage for its administrative expenses.

Cluster Organization and Administration

A new cluster can be started by anyone who meets the requirements, but a cluster can be disbanded if it ever fails to meet minimum standards set by the school board (and individual personnel can be "disbarred" if they are found by the district review board to be negligently unprofessional). It is probably wise to specify a minimum of two or three guides for forming a cluster. Training and certification are required for anyone who wants to be a guide. This training and certification would be provided by schools of education that have been certified by the Institute. Some local training may also be required regarding the district's computer-based advisement and management system and current learning labs. The master guide is chosen by the guides that comprise the cluster, and a 2/3 majority is required to replace the master guide.

For an established cluster, the hiring of new guides is decided by a 2/3 majority of the cluster's guides. The firing of a guide would be based on standards that are clearly laid out in the charter of the cluster or school district regulations, but those standards should allow a sufficient length of time for new guides to improve and for older guides to reform their ways. Because of the importance of cluster cohesiveness and cooperation among guides, a simple majority is sufficient for a cluster's guides to decide whether or not the criteria for release have been met. There is no grievance or appeal procedure, again because of the importance of cluster cohesiveness and cooperation among guides. There is no grievance procedure when a lawyer or doctor is kicked out of a law firm or medical clinic, but such is extremely rare.

An administrative person from the district office is in charge of the accounting, reporting, and logistical aspects for all clusters within the school district, but the cluster decides how its budget will be spent. This frees the head guide to concentrate on instructional concerns and school climate.

It was mentioned earlier that each cluster's gross income is dependent on the total demand for its guides. A point system is used whereby each guide receives 3 points for being the first choice of a "new" student, 2 points for being the second choice, and 1 point for being the third choice. A "new student" is one entering a new level of development, one entering the school system for the first time, or one requesting a new guide after the six-month trial period. The "income rate" for each cluster is determined solely by the cluster's total points divided by the number of guides in the cluster. The cluster's budget is then determined by adjusting that income rate according to the average per cent of "full capacity" for its guides (determined by the actual number of students divided by the full-load number of students for each developmental level). In turn, the guides' salaries are based only on cluster budget and individual load -- no merit -- and are a per cent of the cluster's gross income. Hence, the only way to increase one's salary, as in a law firm or medical clinic, is to increase the demand for the cluster's guides. In this way, there is a tremendous incentive to cooperate within each cluster. All master guides receive a fixed salary supplement set by the school board.

It might be beneficial to have two levels of guides based on merit, such that a beginning guide would likely not receive the same salary rate as a veteran guide. However, this raises difficult questions as to who should make the promotion decision. Alternatively, it might be beneficial to allow each cluster to set its own salaries, for the guides will know that if their other budget categories suffer, parents will be displeased and the cluster's points -- and budget -- for the next year will be lower.

Some districts may also want to allocate a certain fixed dollar amount per student to each cluster's budget, to partially even out the expenditures per student across clusters. However, it should be understood that the more the cluster (and lab) budgets are influenced by demand for them, the easier it will be for superior ones to grow and thereby offer a better education to more students in the district. It will also be less necessary for the district office to close down weak clusters (or labs) by executive mandate, which is likely to be politically difficult, if not impossible. This will be less necessary because insufficient personal incomes will lead the guides in less successful clusters to seek more lucrative positions on their own initiative. In the long run the community will be better off by rewarding excellence and not encouraging mediocrity to linger on.

Learning Lab Management Organization

There is a Learning Lab Management Organization which has the following responsibilities:

- It surveys the needs of the clusters for external instructional support (from labs) and prioritizes those needs.
- It contracts new learning labs. These may be (1) part-time individuals (e.g., a retired biologist who lives in the community and is willing to devote a part of her time to the school district), (2) part-time organizations (e.g., a local museum or business which is willing to devote a part of its time to the school district), (3) full-time individuals (e.g., a mechanic who would like to quit his job and work full-time with kids), and (4) full-time organizations (e.g., a publishing company that has established a subsidiary for running learning labs in schools across the country).
- It trains lab directors whenever necessary, and it provides professional development support services to the labs upon request.
- It distributes money to the labs according to the amount that each lab is used.

An administrative person in the district office is responsible for the accounting, reporting, and logistical aspects for all labs within the school district, but again each lab decides how its budget will be spent.

Consumer Aid Agency

The district-wide Consumer Aid Agency which was mentioned earlier serves (1) as a placement counseling service for matching children with guides and (2) as a watchdog service for providing "consumer reports" on clusters, guides, and learning labs (explained below). This Consumer Aid Agency is run by parents (many on a volunteer basis) but receives a permanent fixed budget (something like one-half of one percent of the total district budget) as part of a system of "checks and balances".

The Consumer Aid Agency's counselling service helps parents to decide which guide will be best for their child. It maintains extensive data on each guide's characteristics and accomplishments, and it diagnoses a child's needs if parents so desire, so as to enable them to select the guides which seem most likely to meet those needs. Such people-categories as "intuiter" and "thinker" may be very useful for part of this function.

The Consumer Aid Agency's watchdog service has responsibility for collecting and disseminating information about the quality of performance of the clusters, guides, labs, and Lab Management Organization.

Given that some parents do not care enough to choose a guide for their child, the placement service diagnoses each such child's needs and applies for the most appropriate guides. However, such applications are not included in the point count described under "Cluster Organization and Administration" above, to avoid the temptation for dirty politics. Federal, state, and local supplements for disadvantaged children would be passed through the district office directly to the clusters' budgets.

Cost-Effectiveness

No thorough cost analysis has been performed as yet, but preliminary indications are that this system would cost approximately the same per student as our present system, yet would be considerably more effective. Although guides are paid more than present teachers, their various assistants (apprentice guides, volunteers, and older students) cost considerably less. Their use enables a much higher student-guide ratio, but with increased human contact and caring.

The learning labs are the element which may most influence costs. The number of labs and relatedly the number of passes provided to students each quarter will greatly influence the cost. Also, the extent to which the labs are staffed and/or directed by volunteers or semi-volunteers (those who accept nominal payment to supplement retirement or other income) will also greatly influence the cost.

In a small school district, it might be wise for each guide to also serve as a lab director, with a fewer students to guide. We presently anticipate that this entire system can be run within present school budgets, especially given that local businesses, foundations, and individuals would be considerably more inclined to sponsor learning labs, including basic-skill and content-area shopping mall labs, as well as more application-oriented and problem-oriented site labs.

CONCLUSION

Much work needs to be done to further develop, field test, and refine this blueprint of a third-wave educational system to the point where we can begin to think about implementing it in a pilot school. And this only represents the first step in a systematic strategy to make significant improvements (a quantum leap) in our educational system. Although the road to meaningful, structural reform of public education is long and difficult, we feel that the strategy and approach are both very sound. With persistance and dedication from a national coalition of concerned citizens, we feel confident that we can achieve very significant improvements. We would be interested in hearing from anyone who would like to be a part of this effort.

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Title:

Perceived Credibility of Female Peer Talent in the Context of Computer Instruction

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PERCEIVED CREDIBILITY OF FEMALE PEER TALENT IN THE CONTEXT OF COMPUTER INSTRUCTION

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PERCEIVED CREDIBILITY OF FEMALE PEER TALENT IN THE CONTEXT OF COMPUTER INSTRUCTION

Introduction and Rationale

The credibility of persons who deliver instructional messages is a key factor influencing the effectiveness of media presentations utilized in educational settings (Fleming & Levie, 1978). Research in the field of communications indicates that a receiver's perception of the speaker's credibility is almost always related in some way to the impact and effectiveness of the message (Andersen & Clevenger, 1963). Thus, those designing and utilizing visual presentations must concern themselves not only with the content of the instructional message but with the credibility of the talent who appears in the visuals.

Talent credibility, however, is known to be affected by a number of variables. These variables include characteristics of the talent, characteristics of the audience, and the influence of the particular topic itself. Since an instructional message is a "pattern of signs (words and pictures) produced for the purpose of modifying the cognitive, affective, or psychomotor behavior of one or more persons" (Fleming & Levie, 1978, p. ix), talent chosen to appear in media productions should be most effective in their ability to influence learners to think, feel, or behave in accordance with specified learning outcomes.

Social learning theory (Bandura, 1969, 1977, 1986; Bandura & Walters, 1963) suggests that visuals can play a role in influencing human behavior as part of a continuous interactive process involving cognition, behavior, and environmental factors. Observational learning is a key component involved in the social learning process and is defined as the "tendency for a person to reproduce the actions, attitudes, or emotional responses exhibited by real-life or symbolized models" (Bandura & Walters, 1963, p. 89). Learning is considered to occur through the observation of symbolized models, such as those appearing in visual presentations, and social learning theory emphasizes the importance of utilizing models who will be viewed as credible by the intended audience. Bandura (1969, 1977, 1986) further indicates that learner characteristics will influence the efficacy of any given model for any given group of observers. Additionally, Bandura suggests that the context in which the models appear will influence observational learning. Thus, a particular model's credibility may vary, depending on characteristics of the model, the audience, and the topic.

Selecting credible talent to appear in instructional media productions on the topic of computers and computer utilization is a challenge for persons interested in designing, producing, and utilizing media presentations for adolescent learners. Numerous articles in the popular press (Elmer-DeWitt, 1986; Horn, 1985; Sealfon, 1986) as well as entire special issues of professional journals (Lockheed, 1985a; Moursund, 1984) have noted an emerging gender gap in computer utilization between female and male learners which becomes most apparent around the time of adolescence. The gender gap is manifested in areas such as enrollments in computer literacy and programming classes, attendance at computer camps, home use of computers, elective time spent in computer activities, and level of elective computer instruction attained. The concern exists that secondary school students are perceiving computer use as a primarily male domain and that capable females are self-selecting out of computer courses and computer related activities. The sex-typing of computer use as an activity inappropriate for adolescent females is believed to reduce females' potential for achievement in computer-related studies and associated careers (Jones, 1983; Moursund, 1984).

A proposed educational intervention to encourage adolescent females to participate in computer activities is to present computer-using female models in both live and mediated observational learning situations. Research on the impact of gender characteristics of instructional materials (Schau & Scott, 1984; Scott and Schau, 1985) indicates that instructional media can either restrict or broaden pupils' attitudes about who can or should participate in activities which are represented in media presentations. Investigation of ways in which instructional media productions can be designed to encourage young females as well as young males to learn about and utilize computers is justified. The selection of credible talent chosen to appear in such instructional media presentations is an integral part of this endeavor.

In selecting credible talent to serve as models for observational learning in the context of computer instruction, characteristics of the talent, characteristics of the learners, and the influence of the topic itself again emerge as primary considerations. Factors relating to the characteristics of the learners and to the characteristics of the talent which may affect the credibility of the talent include the age and gender of both the observer and the model. Peers are known to be effective role models in certain circumstances (Cantor, Alfonso, & Zillmann, 1976; Conger, 1973; Kimmel & Weiner, 1985; Lueptow, 1984; Schunk, 1987; Weitzman, 1979). Learners may find talent of the same gender as their own to be most credible (Pearson, 1982a, 1982b; Schau & Tittle, 1985; Schunk, 1987). By observing peer models, adolescents learn about and often adopt attitudes and behaviors which they feel are appropriate for their gender as well as for their age (Kimmel & Weiner, 1985; Lueptow, 1984; Schunk, 1987). However, the tendency to sex-type computers and computing as an activity more appropriate for males than for females (Campbell, 1984; Elmer-DeWitt, 1986; Lockheed, 1985b; Sanders, 1985; Sanders & Stone, 1986; Schubert, 1984) conceivably affects the perceived credibility of female peer models appearing in instructional presentations on computer use.

Female talent might not be perceived as credible, solely on the basis of gender, when presenting information pertaining to the traditionally male domain of computers and computer use. Because adolescent females are considered to be the learners at risk in terms of computer instruction, and because the credibility of female talent for both female and male learners is unknown in this context, the present study specifically investigated the credibility of adolescent female talent within the context of computer instruction. Both female and male adolescents observed computer-using female models, and the gender of the learner served as an independent variable in the present study.

Another gender-related social message about computers which learners may receive is that computing is a solitary activity and therefore more appropriate for males. Lueptow (1984) suggests that traditional sex role stereotypes associate the female sex role with the characteristics of expressiveness, affective concern, relationship-orientation, nurturance, communion, and cooperation. The male sex role is traditionally associated with characteristics such as independence, self-sufficiency, task-relevant orientation, autonomy, self-reliance, and individualism. As Lueptow and others are quick to note, these qualities associated with female and male sex roles are generalizations and are neither good nor bad, but emerge as characteristics with which female and male sex roles traditionally have been associated.

These patterns of adolescent sex role development indicate that females are encouraged to form social relationships and to focus on interpersonal activities, which conflicts with the ways in which computer utilization often is portrayed and taught. Studies conducted by equity organizations indicate that adolescent "girls generally prefer people to things and enjoy working in groups more than pursuing solitary activities. Friendships and social interactions are important at this age but are rarely encouraged in computer work" (Sealfon, 1986, p. 54). The presence of other female friends and the ability to work in pairs at a single machine are strong inducements for female adolescents' participation in computing activities, with the implication for educators being "to encourage groups of girls -- friendship groups -- rather than individual girls to use the computer" (Sanders, 1985, p. 26). It is conceivable that portraying female computer-using talent in pairs rather than as individuals may indicate to female learners that computer use is an activity in line with the traditionally female concerns for friendships and cooperation. Schunk (1987) also notes that multiple models may increase the effectiveness of observational learning situations. Such paired portrayals may affect the credibility of the talent appearing in instructional presentations. Individual or paired female talent was a second independent variable in the present study.

Another potential influence on perceived credibility of the talent is a learner's attitude toward the topic of instruction. Bloom's (1976) theory of school learning suggests that attitudes toward a topic which students bring with them to the instructional setting will influence both cognitive and affective learning outcomes. Reece and Owen (1985) corroborate Bloom's research within the context of computer instruction. Learners' existing attitudes toward computers may influence their perceptions of the credibility of the talent appearing in instructional media presentations on computer utilization. Learners' attitude toward computers served as an independent variable during the study.

This study examined adolescent learners' perceptions of talent credibility in the context of media presentations on computer utilization. Specifically, the study investigated the effects of 1) learners' gender, 2) learners' attitudes toward computers, and 3) presentation of individual or paired female peer talent on eighth grade learners' ratings of perceived talent credibility. The study sought answers to the following questions:

1. Is perceived talent credibility affected by learners' gender?
2. Is perceived talent credibility affected by learners' attitude toward computers?
3. Is perceived talent credibility affected by the number of female talent appearing in each visual?
4. Is perceived talent credibility affected by interactions between or among learners' gender, learners' attitudes toward computers, and number of talent?

Method

Subjects

Subjects for this study were 96 eighth grade student volunteers (56 females, 40 males) enrolled in careers and communications classes at a middle school (7th - 8th grade) located in the metropolitan Oklahoma City area. Seventy percent of all students enrolled in the school take the careers and communications classes. Subjects ranged in age from 13 to 15 years, with the majority of the participants being 14 years old. Ethnic distribution of students in the school was 95% Caucasian with the remaining 5% of students representing Mexican-American, Black, Vietnamese, and American Indian students. Students in this particular school district had been briefly introduced to computers at the elementary school level, but the middle school had no formal computer education program. Some students had access to microcomputers in the school media center, homes, or parents' place of employment.

Materials

Part I of the Minnesota Computer Literacy and Awareness Assessment, Form 8, (Anderson, Klassen, Krohn, & Smith-Cunnien, 1982), hereafter referred to as the MECC assessment, was used to determine learners' extant attitudes toward computers at the beginning of the study for purposes of randomly assigning students to treatment groups. An alpha reliability of .85 was obtained using the instrument in the present study, which adds credence to its status as an appropriate instrument to use in similar situations.

Perceived talent credibility was quantified using a scale adapted from the McCroskey Scales for the Measurement of Ethos (1966), with content and face validity of the adapted instrument verified by experts in the field of communications. As with the original instrument, talent credibility scores were composed of two subscales: 1) authoritativeness (competence) and 2) character (trustworthiness). The internal consistency for the first and second administrations of this scale during the current study were .95 and .96 respectively. Cronbach alpha reliabilities for the authoritativeness subscale were .94 and .95 for the first and second administrations of the instrument, while alpha reliabilities for the character subscale were .92 and .95 respectively. These results indicate that this instrument may prove useful in future research to measure the perceived credibility of talent delivering instructional messages about computers.

Students also answered open-ended questions about their perceptions of the overall credibility (authoritativeness and character) of the talent. At the conclusion of the treatment sessions, students responded to open-ended questionnaires asking them to describe classroom situations in which they would most like to learn about using computers.

Four short slide-tape shows were produced by the researcher which depicted individual or paired female talent delivering the introduction to a media presentation on computer utilization. Talent were selected who were similar to the majority of subjects in age and ethnic background. The two 14 year-old females selected as talent dressed similarly and were photographed working as individuals and also working in pairs in a computer classroom. Care was taken to duplicate the positioning, expression, and overall content of each scene as the talent were changed. An adolescent female with an articulate, pleasant voice served as the narrator. The same taped version of the narration was used in each of the treatment conditions.

To control for variables other than individual or paired presentation which might contribute to the perceived credibility of the talent, counterbalanced treatment materials were prepared. To help control for differences in physical appearance of the two talent, Talent A appeared as the individual talent in one treatment and Talent B appeared as the individual talent in another treatment. The two females also appeared together in versions of the paired talent treatment. One paired version portrayed Talent A as the main or central focus of the photograph, with Talent B also appearing in the slide (Talent A/Talent B). The other version portrayed Talent B as the central figure, with Talent A appearing as the second adolescent involved (Talent B/Talent A). Controlling for order effects dictated four treatment groups in which students viewed either individual or paired presentations in differing order: 1) Talent A first, Talent B second, 2) Talent B first, Talent A second, 3) Talent A/Talent B first, Talent B/Talent A second, and 4) Talent B/Talent A first, Talent A/Talent B second. Though four treatment groups were utilized, results from the appropriate groups were combined to yield individual treatment data and paired treatment data.

Procedure

The MECC attitudinal assessment was administered to 96 initial participants in their respective classrooms during four consecutive class periods. Taped directions were played by a female adult proctor and the regular male teachers were present in each classroom during the administration of the instrument. As was the case with all test materials, students' names and additional information had been coded onto answer sheets prior to their distribution. For both the MECC assessment and the Perceived Talent Credibility scales, students marked their responses to Likert-type questions directly on computer answer sheets. Responses were optically scanned and scored, and 10% of the response sheets were hand checked and found to be accurately processed by the computer.

Statistically significant differences were found in the scores between female learners ($\underline{M} = 71.50$) and male learners ($\underline{M} = 76.33$) on the MECC assessment, $\underline{t}(72.70) = 2.09$, $\underline{p} < .05$, two-tailed. For this reason, female subjects were categorized as having positive attitudes toward computers if their scores were above 72 and negative attitudes toward computers if their scores were 72 or below. Similarly, male subjects whose scores were 76 and above were considered to have positive attitudes toward computers while male subjects with scores falling below 76 were categorized as having negative attitudes toward computers. After female and male participants had been categorized as having positive or negative attitudes toward computers, stratified random assignment by gender and attitude toward computers was used to assign students to one of four treatment groups.

Three days later, 91 students present to participate in the remainder of the study were directed to one of four classrooms where they viewed the appropriate versions of the slide-tape presentations and completed the Perceived Talent Credibility scale during their regular 55-minute class periods. Tape recorded instructions to the students were administered by adult male teachers who directed the data collection procedures in each classroom. Students in each treatment group viewed a slide-tape presentation and then answered both the multiple choice and open-ended questions regarding perceived talent credibility. Student responses to the first presentation were collected, and each group of students then viewed the second slide-tape production. Students again answered the questions regarding the perceived credibility of the talent and an open-ended question on their preferences for classroom situations in which they would most enjoy learning about computers.

Results

Main and Interaction Effects

A three-way factorial analysis of variance (ANOVA) was used to determine whether the dependent measure, perceived talent credibility scores, was affected by learners' gender (female or male), learners' attitude toward computers (positive or negative), number of talent (individual or paired), or interactions between or among these independent variables. With alpha set at .05 and power set at .80, a medium-large effect size of approximately .30 would have been detected with the sample size of 91 subjects. No significant main or interaction effects were detected at these levels. The main effect for learners' attitude approached significance ($p=.057$). There was a consistent trend for students to assign slightly higher credibility scores to individual rather than paired talent, regardless of the subjects' gender or attitude toward computers. The combined effects of learners' gender, learners' attitude toward computers, and presentation of individual or paired talent accounted for 8.5% of the total variance in perceived talent credibility scores.

In analyzing the subscale for authority of the talent, main and interaction effects were not significant. The combined effects of learners' gender, learners' attitude toward computers, and presentation of individual or paired talent accounted for 7.4% of the variance in scores for the subscale measuring talent authoritativeness.

In analyzing the subscale for character of the talent, the mean score for subjects with positive attitudes toward computers was 130.48, and the mean score for students with negative attitudes toward computers was 123.32. The ANOVA indicated a significant main effect for learners' attitude, $F(1, 83) = 3.98$, $p<.05$. Other main and interaction effects were not significant. The combined effects of learners' gender, learners' attitude toward computers, and presentation of individual or paired talent accounted for 11.8% of the variance in scores for the subscale measuring talent character.

Open-ended Responses

In responses to open-ended questions, the most frequent reason students cited for perceiving the talent as credible was the fact that the talent had been chosen to appear in a media presentation. Because talent had been selected to appear in an instructional production, subjects believed them to be both competent and trustworthy sources of information about computers. The most frequent reason cited for not perceiving the talent as credible was lack of substantial, in-depth computer related content in the slide-tape program.

When asked whether they would rather work with a computer alone or with a friend, chi square calculations revealed a statistically significant difference between the responses of females and males. Females expressed more frequent preferences for using computers with a friend than did males: $\chi^2(1, \underline{N} = 88) = 3.84$, $\underline{p} < .05$. Females with positive or negative attitudes toward computers did not differ significantly from each other in their preferences for working on computers alone or in pairs. Seventy-three percent of all females indicated a preference for working on computers in pairs, regardless of their attitude toward computers. Males with positive attitudes did not differ significantly from males with negative attitudes, with fifty-three percent of all males indicating a preference for working on computers in pairs, regardless of their attitudes toward computers. No significant relationship was found between gender of students with positive attitudes toward computers and their stated preferences. Chi square calculations revealed a significant relationship between gender of students with negative attitudes toward computers and their preferences for using computers, with females preferring to work with a friend: $\chi^2(1, \underline{N} = 42) = 7.74$, $\underline{p} < .01$.

Discussion

Main and Interaction Effects

Several considerations are raised by the failure of the three-way ANOVA to detect significant main or interaction effects upon perceived talent credibility scores. Data indicate that the gender of the learner did not affect the perceived credibility ratings of female peer talent appearing within the context of computer instruction. Data collected in the open-ended questionnaires indicate that the fact that a particular talent had been chosen to appear in an instructional presentation contributed to the credibility of the talent. Apparently, learners of both genders were willing to believe that female talent who appeared in media presentations were both competent and trustworthy or they would not have been selected to serve as talent. Results of this study support the proposition that, in light of recent calls for computer-using female role models, female peer talent may be used in instructional presentations without jeopardizing the talents' credibility for female or male learners.

The main effect for differences in perceived credibility scores for learners with positive or negative attitudes toward computers approached significance. Statistically significant differences in scores on the character (trustworthiness) subscale were found for learners with positive or negative attitudes toward computers. These results suggest that attitude toward a topic influences the credibility of a talent delivering instructional messages. Subjects with positive attitudes toward computers rated talent higher in credibility than did students with negative attitudes toward computers. Bloom (1976) stresses the importance of initial attitude toward a subject or task as a major factor influencing both cognitive and affective learning outcomes, and it appears that initial positive attitudes towards a subject may increase the credibility of the talent delivering information on that topic as well. Specifically, it appears that learners with positive attitudes toward computers perceive talent as more trustworthy than do learners with negative attitudes toward computers.

No main effect for individual or paired talent presentation was found, though a consistent trend indicated that learners, regardless of gender or attitude toward computers, rated individual talent slightly higher in perceived credibility than paired talent. One possible explanation is that individual talent versions suggested to the audience that the talent was an expert while paired talent versions suggested a subtle lack of expertise on the part of each individual. Since students viewing the paired treatment versions had less variety in the visual presentations than those subjects who viewed individual versions, boredom was considered a potential reason for slightly lower credibility scores. However, credibility scores of individual talent were slightly higher than paired talent scores on the first administration of the instrument as well as on the second, discounting this possibility. Results of this study indicate that the presence of individual or paired female peer talent made virtually no difference in perceived credibility scores for eighth grade learners.

No interaction effects were found to exist. However, the median split procedure used to assign learners to groups of students with positive and negative attitudes toward computers may have obscured results which might have been found using extreme group comparisons. The current study was conducted utilizing the median split procedure as it was thought to be a more true reflection of conditions existing in actual classroom learning situations. Again, options for future research exist. Additionally, the combined effects of learners' gender, learners' attitudes toward computers, and presentation of individual or paired female talent accounted for only 8.5% of the total variance in perceived talent credibility scores. This finding indicates that other factors not investigated in this study contribute to the perceived credibility of talent appearing in instructional media presentations and suggests an avenue for further research.

Open-ended Responses

Of the subjects who did not believe the talent was credible, the majority cited the failure of the talent to provide them with substantial computer-related information as the reason for low talent credibility. Of the subjects who found the talent to be credible, the majority stated that they did so because they had learned something about computers from the presentation. Research (Andersen & Clevenger, 1963; Bowers & Phillips, 1967; Brock, 1965) indicates that the inclusion of specific content into the treatment presentations may introduce extraneous variables into the ratings of perceived talent credibility, therefore the slide-tape treatments had been designed to be as free from specific computer-related content as possible. Data from the open-ended questionnaires support the contention that the informational content of an instructional message will influence the perceived credibility of the talent and that viewers may judge the credibility of the talent by comparing what the talent says to the learner's personal expertise.

Viewing individual or paired talent presentations had no relationship to students' stated preferences for working with computers alone or with a friend as indicated in open-ended responses. However, responses to the questions did suggest that students' gender and attitude toward computers were related to their preferences for working alone or in pairs. Female students, in comparison to male students, were found to express a statistically significant preference for working on a computer with a friend. This relationship appeared to be most influenced by female learners with negative attitudes toward computers. Females with negative attitudes, in contrast to males with negative attitudes, expressed a significant preference for learning about computers with a friend. Gender was not related to preferences of students with positive attitudes. These findings lend support to the idea of teamwork as a proposed educational intervention for encouraging females to participate in computer learning activities (Sanders, 1985; Sanders and Stone, 1986) and suggest that working in pairs may be an especially attractive option for females with negative attitudes toward computers. Further research in this area is warranted. Additional research is also needed to determine more specific effects of talent credibility upon cognitive and affective learning outcomes when computers are the subject of instruction.

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Title:

Instructional Technology Academic Preparation, Competency, an On-the-Job Success

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Preparation, Competency, an On-the-job Success

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A paper presented at the 1988 Annual Meeting of the Association of Educational Communications and Technology, New Orleans, LA. January 15-19, 1988.

Background and Issues

Instructional Technology graduates work in diverse settings, principally educational systems (both K-12 and higher education), private sector training environments, and health and human service training departments. Consequently, Instructional Technology (IT) academic programs cover a broad range of skills and application techniques, and the students are as diverse as their vocational aspirations, more varied than other students in schools of education.

This study is a follow-up of one particular group of IT graduates. It looks at their demographics characteristics, their jobs, the programs they elected, and their perceptions of their own competence. Moreover, since Instructional Technology is becoming more and more intertwined with adult learning issues, these graduates are seen as adult learners and the findings are discussed in light of that literature.

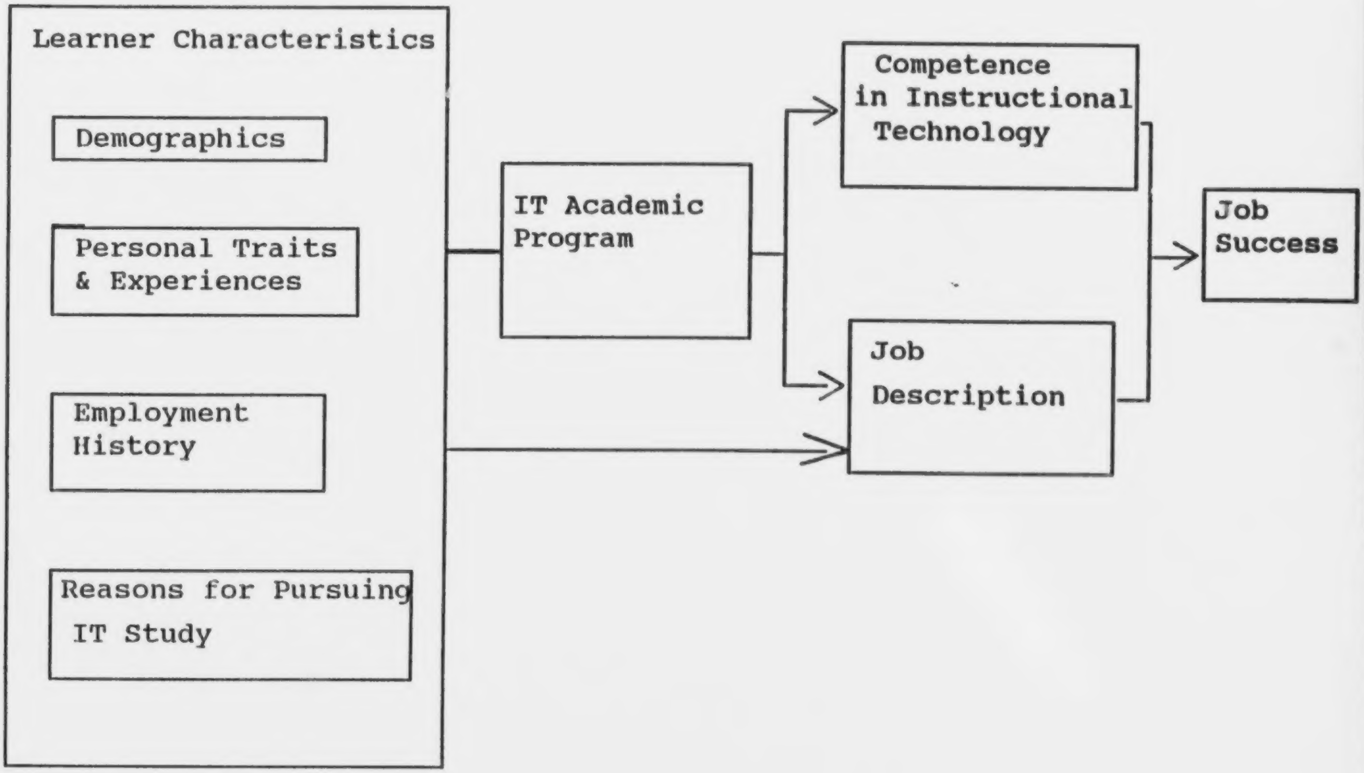
Most adult learners are not in higher education programs (only 14% are, according to Aslanian and Brickell, 1980). The graduates are thus not representative of adult learners, in general. However, they are typical adult learners in that their interests are primarily job-related (Darkenwald and Merriam, 1982). In addition, the graduates in this study seem typical of many professionals of the future because of their interest in career changes. Over forty percent reported that the primary reason they began this graduate program was to enable them to change careers, primarily from teaching positions to private sector training.

As with many follow-up studies, this one is concerned with both the competency of the graduates, as well as on-th-job success, and the extent to which these results can be attributed to the academic program. However, other variables have also been included because of the adult learning context. Previous studies of adult education participation have highlighted the importance of certain demographic characteristics (e.g. age, sex, and socio-economic status), and life experiences (Aslanian and Brickell, 1980; Cookson, 1986; Scanlan, 1986; Shipp and McKenzie, 1981). In addition to these, this study considers the role of certain affective characteristics of the graduates. These types of variables have explained much of the achievement of children in school situations (Bloom, 1976), and similar findings have been reported for adults (Cookson, 1986; Darkenwald and Valentine, 1985; Stamatis, 1986).

Figure 1 below summarizes the model of variable clusters which served as the framework for this study.

FIGURE 1

A Model of Variable Clusters
Relating to Competence in Instructional
Technology and On-the-job Success


Learner Characteristics
Demographics
Personal Traits & Experiences
Employment History
Reasons for Pursuing IT Study
IT Academic Program
Competence in Instructional Technology
Job Description
Job Success

Research Goals of the Study

The specific research questions explored in this study are:

1. What are the relationships between self-assessed competency levels and learner characteristics, including:
    a. demographics (sex, age, marital status, and educational background),
    b. situational background (activity level, and number of children),
    c. personality self-assessments (assertiveness, leadership, human interaction),
    d. employment experiences (settings, job title, income level), and
    e. reasons for program participation.

2. What are the relationships between self-assessed competency levels and academic program characteristics, including:
    a. total number of courses elected, and
    b. type of track elected.

3. What are the relationships between self-assessed competency level and key employment characteristics, including:
    a. current income,
    b. employment setting,
    c. job title, and
    d. on-the-job use of IT skills.

4. What are the relationships between current income and key learner characteristics, including:
    a. demographics (sex, age, marital status, and educational background),
    b. personal background (activity level, and number of children),
    c. personality self-assessments (assertiveness, leadership, human interaction),
    d. employment experiences (setting, job title, income level), and
    e. reasons for program participation.

Procedures

Population

The population of this study was the 1980-1985 graduates of the Wayne State University Instructional Technology programs. These include students with Master's Degrees, Educational Specialist Certificates, and Doctorates (both Ph.D and Ed.D). There are currently 404 active IT students in these programs (264 at the masters level, 53 educational specialists, and 87 doctoral students, of which 71 are in the Ph.D program). Almost all of the students are enrolled on a part-time basis. Wayne State University is an urban, research university in Detroit, Michigan with approximately 30,000 students. The University is close to major training and development departments housed throughout the automotive industry, computer manufacturing organizations, public utilities and insurance companies. These organizations provide diverse sites for practical applications in the IT program, as well as subsequent employment opportunities for graduates. The five county area also has K-12 employment sites, and large intermediate school districts, many community colleges, and other four-year colleges and universities.

Data Collection and Instrumentation

A mail survey instrument was constructed which covered all of the variables for the study. The instrument also included a self-assessment of 56 IT competencies.

The competency list (See Appendix A) was based upon several other documents identifying critical IT competencies. The first list used was the core competencies for instructional/training development developed by the Task Force on ID Certification of the AECT Division of Instructional Development (Task Force on ID Certification, 1981). Secondly, competency lists used by private organizations for employee evaluations were used. These lists were combined and standarized in format. Finally, changes were made to be congruent with the Wayne State IT program.

Surveys were mailed to 263 graduates. Fifty-eight were returned because of inaccurate addresses; thus the population was reduced to 205 graduates. With a 37% return rate, the total number of responses available for analysis was 75. There was no follow-up to non-respondents.

Date Analysis Methods

The model shown in Figure 2 provided the initial hypotheses. Path analysis was conducted to evaluate and more fully define this model.

Job success (see Figure 2) was measured by self-reported 1986 income. Job description was measured by job title and employment setting, and the frequency with which the graduates used the 56 IT competencies. The IT academic program was first described by simply identifying the total number of Instructional Technology and Evaluation and Research courses elected. Then the program was described by more specific program tracks.

These tracks were determined by: 1) identifying those courses commonly elected that form the core of classes, and 2) performing a factor analysis of the remaining course election data to identify distinctive patterns of course election. The common core group was separated from the analysis since it represented the least variance. Graduates were identified with the track in which they had elected the largest fraction of courses when compared to the other tracks. These tracks were then used to distinguish the various academic programs of the graduates in this study.

Two Models of the Effects of Academic Preparation in Instructional Technology

The intent of the study was to investigate the links between the characteristics of students, academic preparation in Instructional Technology, competency attainment, and on-the-job success. The major conclusion that can be drawn from the data is that interactions do not exist between all of these variables. It seems that there are two distinct models. The first explains the links between learners' characteristics (demographic, situational, and occupational) and their reasons for program participation and on-the-job success, as defined by income level. The nature of the academic program or the level of competency attainment can not be seen as predictors of job success in this model. The second model explains competency attainment in terms of the academic program, the frequency of use of the various IT skills on the job, and learner characteristics, primarily personality variables. These two models will be described in the following section.

A Model of IT Program Participation and On-the-Job Success

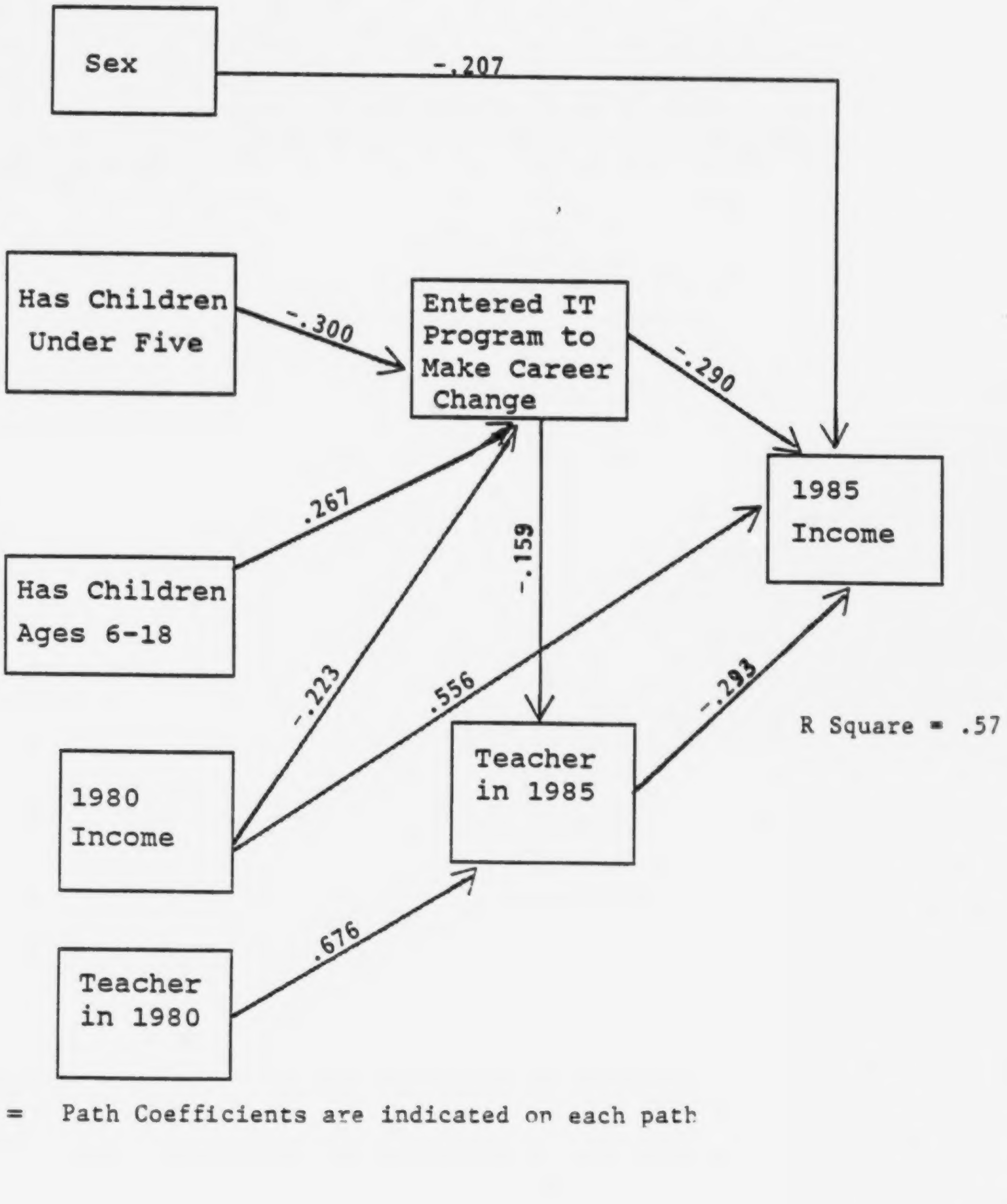
The model in Figure 1 shows the effects of Instructional Technology program participation on the 1985 income of graduates. This is a model which focuses on life experience variables, both family and professional, as motivation for program participation. It also tends to explain what can depress income, rather than explain high incomes.

Demographic Characteristics of Learners The only significant demographic characteristic to explain income level is sex. (See Table 1 in Appendix B for the data supporting the relationships found between the causal variables and the endogenous variables and the dependent variable, 1985 income.) As has been repeatedly reported, females earn lower salaries than males. The results of this study are no different. Being female explained lower salaries.

It is interesting to note that the male-female split in this study was almost precisely the split that has been found among adult learners in general (Aslaniane and Brickell, 1980), a 49%-51% division. This is true even though the IT population is not representative of the typical adult learner in other respects, principally age, education level, and employment rate. (See Appendix C for the demographic data comparing the IT graduates to general adult learners.)

Figure 2

A Model of Instructional Technology Program Participation and its Effects upon on-the-job Success*


Sex
-.207
Has Children Under Five
-.300
Entered IT Program to Make Career Change
-.290
1985 Income
.267
-.159
Has Children Ages 6-18
-.223
.556
-.293
R Square = .57
1980 Income
Teacher in 1985
.676
Teacher in 1980

* = Path Coefficients are indicated on each path

Personal Traits and Experiences. Anslanian and Brickell's (1980) extensive study of life changes as reasons for the causes and timing of adult learning identified a cause and effect relationship between life circumstances, which preceeded transitions, and learning. In this study, the situational variable which most affected an individual's motivation to begin graduate study were the ages of his or her children. This is evident, however, only in the cases of those students who entered the IT program with the intention of making career changes. In such instances, both men and women delayed starting graduate study until their children were in school.

Given the previously discussed effects of being female on income level, the effects of an interaction between being female and having children were also examined. This process did reveal some effects, but only of an indirect nature. The interaction between females and children does not explain 1985 income, nor job titles, nor reasons for IT program participation. What was discovered was that the 1980 income was negatively effected by this combination. Therefore, since the 1980 income is a powerful predictor of the 1985 income, the effects of this interaction are important.

Employment History. The graduates' occupational experiences proved to be key variables in both models which have emerged from this study. Here, it precipitated enrollment in the IT program for many. A low income in 1980 seemed to motivate the career changers to pursue graduate study.

Being a teacher explained the lower 1985 salaries in this study; although conversely it was not true that holding other job titles explained the higher incomes. Nevertheless, there was a tendency for the highest incomes to be earned by those in non-education settings, or by those who were in education, but not classroom teachers (primarily school administrators).

Reasons for Program Participation. A central part of the on-the-job success model is the role of the reasons students had for initially entering the IT graduate program. Data was collected in relation to three reasons for graduate study -- to obtain an advanced degree, to prepare for advancement in one's current job, and to prepare for a career change. The latter reason proved to be a predictor of 1985 income.

The major difference between the career change sub-group and the total population of the study is that the former group did appear to make the desired job changes. In 1980, 50% of those who intended to change careers were employed as teachers; 19.7% were employed in non-education jobs and nearly 13% were unemployed. Five years later no one was unemployed, 40.7% were working in non-education jobs, and just under 30% were still teachers.

However, making these career changes seems to have had a depressing effect upon salaries. It is hypothesized that since these persons have been in their new positions for a relatively short period of time, they have not yet begun to advance and salaries are, therefore, lower.

A Model of Academic Preparation, On-the-Job Skill Use and Competency Attainment

The second model resulting from this study emphasizes the IT academic program itself and the extent to which competencies were acquired, as measured by self-assessments. While life experiences were important to program participation, the critical learner characteristics in this context are personality variables. The important job descriptors are the extent to which the various IT skills are used in the workplace. The model is shown in Figure 3 below.

Demographic Characteristics of Learners. Again, the only major demographic predictor (now in relation to competency self-assessment) is sex. However, rather than having a negative impact as with salaries, being female is linked here to higher competency assessments. (See Table 2 in Appendix B for the data relating the causal variables to the endogenous variables and to the dependent variable, the average of all IT competency self-assessments.) While sex is not as strong a predictor in this model as in the previous situation, the contrasting results are nevertheless noteworthy. Either the women graduates are giving themselves positively biased competency ratings, or there is little correlation between skill and income.

Personal Traits and Experiences. Respondents rated themselves in terms of three personality traits -- assertiveness, leadership, and outgoingness. While leadership abilities did not predict competency attainment, the other two variables did have a positive, though indirect, relationship to overall competency self-assessment.

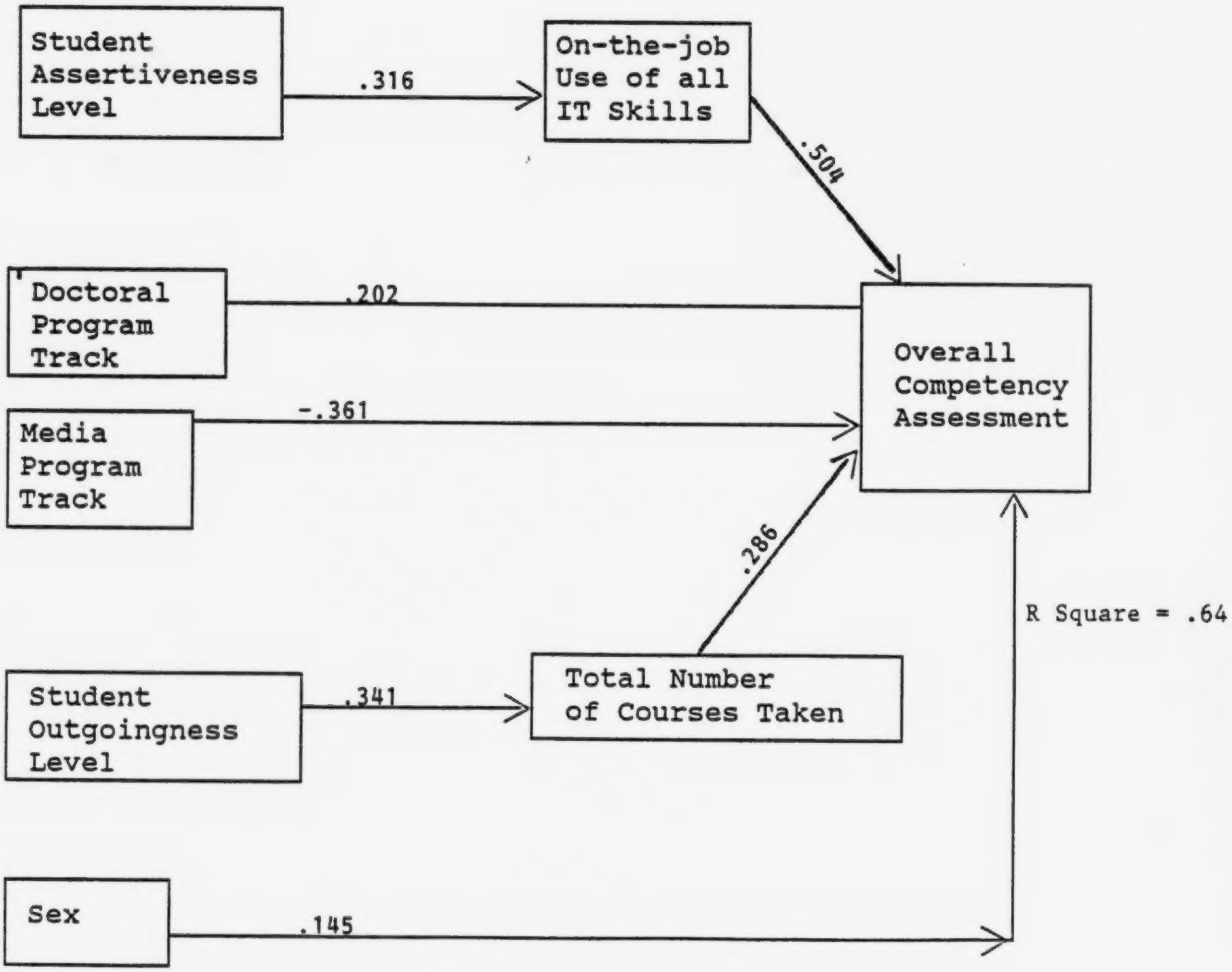
Assertiveness was linked to the on-the-job use of IT skills. This may indicate that in the workplace self-initiative explains the scope of some jobs. In addition, those persons who saw themselves as being more outgoing tended to take more university classes. Perhaps the social aspect of graduate programs is satisfying and contributes to competency attainment.

The IT Academic Program. As a result of the analysis of data rather than prior program definition), the IT courses elected by the respondents of this study were divided into a core set of courses and four separate tracks. (See Appendix D for these courses and the percentage of the respondents who elected each course). The four course groups are: 1) the doctoral track, 2) the private sector training track, 3) the media track, and 4) the school track.

The total number of courses taken positively predicts overall

Figure 3

A Model of Instructional Technology Academic Preparation, On-The-Job Skill Use, and Competency Attainment*


Student Assertiveness Level
.316
On-the-job Use of all IT Skills
.504
Doctoral Program Track
.202
Overall Competency Assessment
Media Program Track
-.361
.286
R Square = .64
Student Outgoingness Level
.341
Total Number of Courses Taken
Sex
.145

* Path Coefficients are indicated on each path

competency assessment. However, only two of the four tracks also are related to the overall average competency rating. The doctoral track, logically, explains higher competency assessments. These students have not only participated in more graduate study than other student groups, but they are superior students in terms of traditional academic standards. On the other hand, the media track has a negative influence on overall competency assessment. There is a danger in concluding that students in this track are less competent than their counterparts in other tracks. It is hypothesized that media-oriented students tend to be more specialized, both in terms of course election and in skill application. Since the dependent variable is an average competency rating for all 56 competencies, this measure may be biased against students with specialized areas of interest. Moreover, the Wayne State program has not emphasized traditional media production; the program is more design-oriented and the student population is skewed towards those in private sector training.

On-the-Job Skill Use. The major predictor of average overall competency assessment is the frequency of use of these same competencies on the job. On separate analyses, this same relationship occurred when viewing the six separate competency categories. This speaks to the great importance of practice and application of skills taught in the university classroom.

Although not reflected in the general model, the most frequently used skills are design skills; analysis skills are the second most frequently used. The least used competencies were in the development category, highlighting the existence of IT specializations in the work place. (See Appendix E for specific data describing the extent of competency use on the job.)

Summary

This study has resulted in two general models. These models theoretically separate academic preparation in Instructional Technology and competency attainment from on-the-job success (as measured by income). The two models also highlight the varying roles of different types of learner characteristics. Academic program participation and ultimately income level is linked to life experiences, while personality variables are associated with IT competency attainment. Thus both models support the need to consider IT students in more dimensions than learning capacities and competence in the discipline.

Unlike most adult learners, demographic characteristics of IT students have only limited effects on achievement in this program. The most notable exception from the norm is the absence of age effects, in this context, age does not have a depressing effect on achievement, even though this IT population is older than most pre-retirement adult learners. However, this phenomenon is consistent with the view that age is less of a deterrent to those who are receiving instruction within their domains of interest and specialization (Richey in press). The only critical demographic variable is sex.

The effects of career changes is important to many IT students. This group has been growing at Wayne State. In this study 73.3% of the career changers began their programs since 1981. In spite of the resurgence of teacher education, the pattern does not seem to be changing to any great extent. Realistic views of the advantages and disadvantages of making career changes should be discussed with students.

The competency attainment model shows the importance of academic coursework, but not without the practice that occurs on a job. Perhaps more emphasis should be given to student internships, and to incorporating real world application assignments into IT classes.

However, one is finally left with the question of the adoptability of these general models to specific areas of Instructional Technology. While the sample in this study is small, the more detailed analyses conducted seem to point to the strength of the general model. In relation to competency attainment, analysis by competency category resulted in essentially the same relationships. Moreover, competency assessment still can not be linked to on-the-job success if the data is analyzed more specifically. Therefore, the general models can serve as the bases of hypotheses of cause and effect relationships. They can lend themselves to expanding the tests of these relationships to other variables, (e.g. other measures of on-the-job success can be tested). The models can serve as one way of viewing standard program follow-up data in ways which shed light on adult learning and the role of key design variables in instructional programs.

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Appendix A
Instructional Technology Competencies

Instructional Technology Competency

ANALYSIS

1. Conduct Job/Task Analysis
2. Analyze Knowledge Structure and Construct a Learning Heirarchy
3. Conduct Problems/Needs Analysis
4. Determine which projects are appropriate for instructional design/development
5. Analyze and evaluate existing instructional systems

DESIGN

6. Define your goals
7. Write Behavioral Objectives
8. Select Appropriate Media
9. Sequence Content
10. Design Lessons
11. Design Workshops
12. Design Courses
13. Design Programs
14. Sequence Learning Activities
15. Design Individualized Instruction
16. Design Group Instruction
17. Design A Total Instructional System

ASSESSMENT AND EVALUATION

18. Write Knowledge Test Items
19. Write Performance Test Items
20. Write Pre/Post Tests
21. Write Prerequisite Skills Test

22. Write Questionnaire/Survey Instrument
23. Design/Conduct Tryout Phases
24. Design Formative Evaluations
25. Design Summative Evaluations
26. Evaluate Instructional Materials
27. Interpret Evaluation Data
28. Write Evaluation Reports

DEVELOPMENT

29. Write Self-Instructional Modules
30. Write Training Manuals
31. Write Learning Guides
32. Write Instructors Guides
33. Write Workbooks
34. Write Job Aids
35. Arrange Copy to Enhance Communication
36. Write Audioscripts
37. Write Sound/Slide Scripts
38. Write Multi-Image Scripts
39. Write Videodisk Scripts
40. Design Computer-Assisted Instruction
41. Design Computer-Managed Instruction
42. Write Role Play, Case Study Simulations
43. Develop Learning Games
44. Write Brochures, Flyers etc.

45. Produce Mediated Instruction

MANAGEMENT

46. Design Instructional Management Systems

47. Plan For Organizational Change

48. Implement Organizational Change

49. Write a Funding Proposal

50. Plan/Manage a Design Project

51. Cost a Job and Develop a Budget

COMMUNICATION

52. Interview Subject Matter Experts

53. Demonstrate Consulting Skills

54. Demonstrate Technical Writing Skills

55. Edit Copy

56. Write Design Procedures

Appendix B

Table 1 Hypothesized Causes of 1985 Income Level

Table 2 Hypothesized Causes of IT Competency Self-Assessment

Table 1

Hypothesized Causes of 1985 Income Level

Endogenous Variable	Causal Variable	B	SE B	T	Prob.
	Constant	.70	.301		
Entered IT Program to Make Career Change	Has Children Under 5	-.37	.152	-2.40	.020
Mean=.419 S.D.=.497	Has Children Ages 6-18	.27	.121	2.19	.032
	1980 Income	-.05	.030	-1.79	.079
	R Square =	.15	N = 74		
	Constant	.13	.075		
Teacher in 1985	Teacher in 1980	.66	.090	7.35	.000
Mean=.400 S.D. = .493	Career Change Intent	-.16	.091	-1.72	.090
	R Square =	.49	N = 70		

Dependent Variable	Causal Variable	B	SE B	T	Prob.
	Constant	6.70	.878		
1985 Income Level	1980 Income	.51	.088	5.83	.000
Mean=7.10 S.D. = 1.91	Career	-1.11	.357	-3.43	.001
	Teacher in 1985	-1.13	.367	-3.08	.003
	Sex	-.78	.371	-2.11	.039
	R Square =	.57	N = 71		

Table 2

Hypothesized Causes of IT Competency Self-Assessment

Endogenous Variable	Causal Variable	B	SE B	T	Prob.
	Constant	1.21	.234		
Average Frequency of on-the-job use of all IT Skills Mean = 1.804 S.D. = .396	Assertiveness	.17	.067	2.58	.012
	R Square =	.10	N = 66		
	Constant	.97	3.77		
Total Number of Courses Taken Mean = 10.947 S.D. = 4.992	Outgoingness	2.57	.96	2.69	.010
	R Square =	.12	N = 75		

Dependent Variable	Causal Variable	B	SE B	T	Prob.
	Constant	1.29	.492		
Average Self-Assessment of all IT competencies Mean = 4.037 S.D. = .688	Average Freq. of use on the job IT Skills	.88	.152	5.77	.000
	Total Number of Courses taken	.04	.012	3.07	.003
	Media Academic Track	-.70	.182	-3.84	.000
	Doctoral Track	.51	.242	2.11	.039
	Sex	.20	.120	1.65	.105
	R Square =	.64	N = 66		

Appendix C

A Description of the IT Graduate Respondents in Comparison to General Adult Learners*

Table 3 - Sex
Table 4 - Age
Table 5 - Marital Status
Table 6 - Highest Degree
Table 7 - Employment Status
Table 8 - Ages of Children

*Data from Aslanian and Brickell (1980)

Table 3

A Comparison of IT Graduates and General Adult Learners: Sex

Sex	IT Graduates (N=75)	Adult Learners (N=744)	Difference (in %)
Male	48.0%	49%	-.1%
Female	50.7	51	-.3

Table 4

A Comparison of IT Graduates and General Adult Learners: Age

Age	IT Graduates (N=75)	Adult Learners* (N=744)	Difference (in %)
26-30	4.0%	20*	-16.0
31-35	25.3	17%	+8.3
36-45	44.0	21	+23.0
46-55	22.7	15	+7.7
Over 55	4.0	20	-16.0

*The adult learner age grouping reported by Aslanian and Brickell (1980) were 25-29, 30-34, 35-44, 45-54, and 55 and older.

Table 5

A Comparison of IT Graduates
And General Adult Learners: Marital Status

Marital Status	IT Graduate (N = 75)	Adult Learner (N = 744)	Difference (In %)
Married	69.3	67.0	+2.3
Single	16.0	14.0*	+2.0
Divorced	10.7	10.0	+.7
Widowed	4.0	9.0	-5.0

*Includes separated (2%) and never married, single

Table 6

A Comparison of IT Graduates and
General Adult Learners: Highest Degree

Education	IT Graduates (N = 75)	Adult Learner (N = 744)	Difference (in %)
Bachelor's Degree	0	130%	-13.0
Master's	38.7		
M.A.+ Additional Hours	17.3	12.0	+85.3
Ed. Spec. Certificate	28.0		
Doctorate	13.3		

Appendix D

A Description of the IT Academic Programs

Table 9	Undergraduate Majors of the WSU IT Graduates (1980-85)
Table 10	A Description of the IT Program Core, the 4 tracks, and the Frequency of Course Election

Table 9

Undergraduate Majors of
The WSU IT Graduates (1980-85)

Major	Frequency	% of Respondents
Education	38	50.7
Liberal Arts	25	33.4
English or Humanities	8	10.7
Social Science	5	6.7
Speech Communications	4	8.3
Computer Sci, Math, or Eng.	4	5.3
Psychology	2	2.7
Natural or Physical Sci	2	2.7
Nursing or other Medical Area	6	8.0
Business Administration	2	2.7
Other	2	2.7

Table 7

A Comparison of IT Graduates and General Adult Learners: Employment Status

Employment Status	IT Graduates (N = 75)	Adult Learners (N = 744)	Difference (in %)
Employed	93.3	71.0	+22.3
Retired	*	9	
Homemaker	1.3	15.0	-13.7
Student	1.3	2.0	- .7
Unemployed	2.7	3	- .4

*Data not gathered

Table 8

A Comparison of Male and Female IT Graduates and Female Adult Learners: Ages of Children

Ages of Children	All IT Graduates (N = 75)	Female Adult Learners (N = 792)	Difference (in %)
Under 5	20.0%	8.0%	+12.0%
6-18	53.4	39.0	+14.4
over 19	25.3	59.0	-33.7

Table 10

A Description of the IT Program Core, the 4 tracks, and the Frequency of Course Election

Program Category	Course Number and Name	Percentage of Respondents who Elected the Course
Core Group	IT 711 Instructional Design	90.7%
	IT 710 Intro. Graduate Seminar	84.0
	IT 714 Seminar in Computer Assisted Instruction	62.7
	IT 715 Educ. Product Eval.	61.3
	IT 611 Systems Applications In Education Planning & Management	60.0
Track 1	EER 763 Fund. of Statistics	33.3%
	IT 811 Adv. Instruc. Design	28.0
Doctoral	IT 815 Needs Assessment	28.0
	IT 810 Program Design	26.7
	IT 818 Readings in IT	18.7
	IT 911 Adv. Research Seminar	16.0
	IT 915 Educational Futures	12.0
	IT 816 Adv. Instruc. Management	9.3
	EER 864 Variance & Covariance	8.0
	IT 910 Issues in IT	6.7
	EER 865 Multivariate analysis	5.3
Track 2	IT 712 Instructional & Organizational Instruction	54.7
Private Sector Training	IT 812 Practicum	40.0
	IT 716 Computer-Managed Instruction	36.0

Program Category	Course Number and Name	Percentage of Respondents who Elected the Course
Track 3	IT 510 Using Audiovisual Methods Materials and Equipment	28.0
	IT 512 Instructional Materials Workshop	21.3
Media	IT 519 Light, Sound, Space and Motion	9.3
	IT 513 Computer Programmed Multi-Image Presentations	6.7
Track 4	IT 613 Individualizing Instruction	50.7%
School-Oreinted	IT 616 Management of Instruction	44.0
	IT 511 Educational Technology	42.7
	IT 512 Instructional Materials Workshop	21.3

Appendix E

On-the-Job Use of IT Skills

Table 11 Competency Categories Ranked in Terms of Frequency of Use on the Job

Table 12 Ranking of Most Used and Least Used Competencies

Table 11

Competency Categories Ranked in Terms of Frequency Of Use on the Job

Competency Category	Average Ranking of Competencies
1. Design	8.9
2. Analysis	16.2
3. Assessment & Evaluation	23.8
4. Communication	25.2
5. Management	39.8
6. Development	45.3

Table 12

IT Competencies Ranked in Order of Frequency of Use on the Job

Rank	Competency	Average Competency
1.	Define your goals	4.7
2.	Write behavioral objectives	4.7
3.	Select Appropriate Media	4.5
4.	Sequence Content	4.6
5.	Evaluate instructional materials	4.5
6.	Sequence Learning Activities	4.5
7.	Design group instruction	4.5
8.	Design lessons	4.6
9.	Design programs	4.3
10.	Analyze & evaluate existing instructional systems	4.2
47.	Write role play, case study, sim.	3.6
48.	Write a funding proposal	3.4
49.	Develop learning games	3.6
50.	Write workbooks	4.1
51.	Produce mediated instruction	3.3
52.	Design computer-managed instruction	3.3
53.	Write sound-slide scripts	3.2
54.	Write audioscripts	3.1
55.	Write multi-image scripts	2.8
56.	Write videodisk scripts	2.7

Title:

The Effects of Computer Animated Elaboration Strategies and Practice on Factual and Application Learning in an Elementary Science Lesson

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Lloyd P. Rieber

THE EFFECTS OF COMPUTER ANIMATED ELABORATION STRATEGIES AND PRACTICE ON FACTUAL AND APPLICATION LEARNING IN AN ELEMENTARY SCIENCE LESSON

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Presented at the Annual Convention of the Association for Educational Communications and Technology, New Orleans, Lousiana, January, 1988

THE EFFECTS OF COMPUTER ANIMATED ELABORATION STRATEGIES AND PRACTICE ON FACTUAL AND APPLICATION LEARNING IN AN ELEMENTARY SCIENCE LESSON

ABSTRACT

The purpose of this study was to examine the effects of animation and practice on factual and application learning in computer-based instruction (CBI). Also studied was the extent to which animation and practice promoted near and far transfer of these learning outcomes. Subjects consisted of 192 elementary school students. The CBI content was an elementary physics lesson in Newtonian mechanics. Two levels of Practice (Relevant Practice, Irrelevant Practice) were crossed with three levels of Graphic Type (Graphic, Animated Graphic, No Graphic) and two levels of Text Type (Text, No Text). No significant differences were found for the between-subjects factors of Practice, Graphic Type, and Text Type. Among the within-subject factors (Learning Outcome, Transfer) a main effect was found for transfer: subjects performed significantly better on far transfer questions than near transfer questions. A significant interaction was detected between Learning Outcome and Transfer: far learning was facilitated for factual learning, whereas no difference in transfer was detected for application learning.

INTRODUCTION

Instructional design has evolved into a complex science involving the manipulation of many instructional variables. Effective delivery of instruction has consistently been the focus of much attention in instructional design. The recent availability of microcomputers has provided designers with many instructional alternatives as well as the need to consider important instructional decisions. The potential of the computer as an effective instructional delivery system has been carefully reviewed and studied (see, for example, Edwards, Norton, Taylor, Weiss & Dusseldorp, 1975; Bangert-Drowns, Kulik, & Kulik, 1985, and Clark, 1985).

Computer technology affords designers with a myriad of useful design options. Features such as immediate and informative feedback, lesson branching, lesson management, and visuals have been discussed and reviewed in length. Designers can also effectively incorporate a wide range of teaching strategies and activities into computer-based instruction (CBI).

Potentially unique features of CBI have been discussed and debated. Some, such as Clark (1983), have cautioned against concentrating too heavily on the features of any one particular medium. Clark has asserted that virtually all results found in CBI research stem from purely instructional variables and are only indirectly associated with the computer. Although controversy remains (see, Petkovich & Tennyson, 1984 vs. Clark, 1983), it appears clear that many features of the computer deserve greater attention among researchers. Animation is one such feature which can be more easily incorporated into CBI than perhaps other delivery systems. Although instruction typically uses animation as an extrinsic motivator, there is a need to investigate the use of animation to directly or indirectly support or enhance instruction. An example of computer animation used directly in instruction is an animated block accelerating down an inclined plane to teach a concept in a physics class. Recent research on the effectiveness of animation as an aid to instruction has failed to demonstrate that animation improves learning (see, for example, A. Caraballo, 1985; J. Caraballo, 1985; King, 1975; Moore, Nawrocki, & Simutis, 1979; Rieber & Hannafin, in press).

The lack of empirical support for animation presents an apparent discrepancy between hypothesized animation effects (as supported by a theoretical perspective of the importance of providing information in verbal and visual representations to promote redundant encoding) and the empirical evidence to date. Research in the area of cognitive psychology points to the apparent retrieval advantages of multiple encoding at the time of learning. Mental imagery researchers (Bower, 1972 and Paivio, 1979) have recognized mental imagery as one of the primary mental structures, along with verbal representations. Many studies (Bower, 1972; Paivio, 1979; Dwyer, 1978) point to the power of pictures over abstract words for purposes of higher levels of retention. The problem seems to rest in the need to define appropriate contexts where the potentially powerful visual effect of animation can be used most effectively.

Practice is another instructional variable which has been studied extensively (Anderson & Biddle, 1975; Hamaker, 1986). Practice in CBI typically comprises a series of questions presented during or following instruction. CBI practice serves three functions: 1) to establish and maintain attention; 2) to facilitate encoding; and 3) to provide opportunities for rehearsal (Wager & Wager, 1985). The application of practice questions during CBI is based on the adjunct questioning research of Rothkopf (1966) and others. CBI studies have shown that practice can be a very powerful influence on student achievement (Hannafin, Phillips, Rieber, & Garhart, in press; Hannafin, Phillips, & Tripp, 1986). Although practice is a proven and robust instructional technique, even current reviewers caution against sweeping generalizations (see Hamaker, 1986). There is a need to study the effects of computerized practice, especially when used in the presence of other complex instructional techniques, such as animation.

There were two primary purposes to this study: 1) examine the effects of animation and practice on factual and application learning in a CBI lesson; and 2) investigate the extent to which animation and practice promoted near and far transfer of these learning outcomes. It was hypothesized that students provided with verbal and graphic elaborations of lesson content would achieve higher posttest scores than groups receiving only verbal or only graphic elaborations. It was further hypothesized that practice would be of greatest value where the elaboration support was minimal.

METHODS

Subjects

The subjects consisted of 192 fourth, fifth, and sixth graders from a rural public elementary school. Participation was voluntary and selection based on parent consent. The subjects represented a typical cross-section of elementary school students. In addition, three fifth grade classes from another public school served as a pilot subjects to validate the materials as well establish reliability on the instruments.

CBI Lesson Content

The CBI lesson used as the instructional content for this study was first developed for a previous study (see Rieber & Hannafin, in press). This lesson described and explained Isaac Newton's Laws of Motion. The lesson material was divided into four parts: 1) introductory material; 2) motion resulting from equal forces in opposite directions in one dimensional space; 3) motion resulting from unequal forces in opposite directions in one dimensional space; and 4) motion resulting from equal and unequal forces in two dimensional space.

The first lesson part introduced the learner to Isaac Newton's formal discovery of certain physical laws. This part also initiated the sequence of learning activities used for the rest of the lesson. Most of the information presented in the first part was factual in nature. The second part introduced the concept that equal but opposite forces are needed to cause objects to stop. This section dealt only with one-dimensional space. The third part expanded this notion to include the effects of unequal forces acting upon a stationary object. The final direction and speed of an object is a combination of all of the forces from both directions. The third part also presented these concepts in one-dimensional space. Finally, the fourth part added the notion of two-dimensional space to the above concepts. Again, the final direction and speed of the object results systematically from the sequence of forces which acted upon it.

All instruction was presented at an introductory level with the technical descriptions of the forces of gravity and friction removed. Approximately 45 minutes was required to complete the lesson.

Lesson Versions

Elaboration strategies were embedded at various locations within the lesson. The locations of these elaboration strategies were determined by the performance of students in a pilot study. The elaboration strategies were added to the lesson in areas found to be the most difficult and needing additional instruction. Two factors (Text Type, Graphic Type) were used to determine the nature of the embedded elaboration strategies: two levels of Text (Text, No Text) were crossed with three levels of Graphic (Graphic, Animated Graphic, No Graphic). The combination of these two factors gave the following treatment permutations: text only, text plus graphic, text plus animated graphic, graphic only, animated graphic only, no text/no graphic.

The text and graphic factors were crossed by a practice factor with two levels (Relevant Practice, Irrelevant Practice). Relevant practice consisted of four multiple-choice questions after each of the four lesson parts: two factual and two application. Feedback in the form of knowledge of correct results was provided. Irrelevant practice consisted of a noninstructional activity which required approximately the same time to complete as the relevant practice. The format of the noninstructional activity was also multiple-choice questions, however, the questions concerned information which was irrelevant to the lesson content.

Dependent Measures

Posttest. A 37-item posttest was developed which consisted of two types of questions: 16 factual and 21 application. These learning outcomes correspond to verbal information and rule-using, respectively, as defined by Gagne' (1977). A multiple-choice question format (1 answer and 4 distractors) was used to test the above learning outcomes. All test questions were presented to the students by computer.

A total of 19 questions measured near transfer and 18 questions measured far transfer: 9 factual questions and 10 application questions measured near transfer; 7 factual questions and 11 application questions measured far transfer. An example of near transfer would be a question presented in the context of a ball being kicked. An example of far transfer would be a question presented using a wooden block instead of a ball. Overall test reliability, as determined during the pilot study, was .91. Content validity was established by an expert panel review.

Student processing time. The time required by students to process each of the instructional frames was also collected. Processing time was measured as the time taken by students to press a key to continue after a screen prompt had been given. Response time was calculated by the computer and rounded to the nearest second.

Procedures

In order to determine the content validity and reliability of the materials as well as to substantiate the instructional design of the materials, a pilot study was conducted using a small sample of fifth grade students. In this pilot study, the four instructional parts (introductory, equal forces in one dimension, unequal forces in one dimension, and unequal forces in two dimensions) were presented in an all-text form without any embedded elaboration strategy. Data from this pilot study was used to determine the validity and reliability of the test items in order to help determine the final selection of appropriate test items. Also, this data was used to determine where supplemental instruction in the form of the elaboration strategies was most needed by students.

In the main experiment, students were randomly assigned to one of the 12 treatment conditions. All treatments and data were delivered and recorded by computer. On average, approximately 45 minutes was necessary to complete the lesson.

Design and Data Analysis

In this study a 3 X 2 X 2 X (2 X 2) completely crossed factorial design was used. Three between-subjects factors (Graphic Type, Text Type, and Practice) were crossed with two within-subjects factors (Learning Outcome, Transfer). The between-subjects factors consisted of: Graphic Type (Graphic, Animated Graphic, No Graphic); Text Type (Text, No Text); and Practice (Relevant Practice, Irrelevant Practice). The within-subjects factors consisted of: Learning Outcome (Fact, Application); and Transfer (Near, Far). A mixed factor analysis of variance (ANOVA) was chosen as an appropriate statistical procedure for the study. This analysis is commonly known as a repeated measures analysis of variance (Winer, 1971). The two within-subjects factors also served as the dependent measures of the posttest.

In addition to the above analysis, a second post hoc analysis of student processing latency of the 17 instructional frames which contained embedded elaboration strategies was conducted using ANOVA procedures.

RESULTS

Learning Effects

The percentage means and standard deviations of posttest scores are contained in Table 1. No main effects were found for Graphic Type, $F(2,180)=.393$, $p=.676$, Text Type, $F(1,180)=.072$, $p=.789$, or Practice, $F(1,180)=.234$, $p=.629$. No main effect was found for Learning Outcome, $F(1,180)=2.285$, $p=.132$. A main effect was found for Transfer, $F(1,180)=4.439$, $p=.037$: learners performed significantly better on far transfer questions than near transfer questions.

No interactions were detected among the between-subjects factors (Graphic Type, Text Type, Practice). However a significant interaction was found for the within-subjects factors (Learning Outcome, Transfer), $F(1,180)=3.911$, $p=.05$. The lesson promoted far learning for factual information, whereas far learning was not facilitated for the acquisition of application learning. A moderately significant interaction was found between the factors of practice and learning outcome, $F(1,180)=3.394$, $p=.067$. When provided with practice, students performed significantly higher on application questions than factual questions.

Insert Table 1 About Here

Processing Time

Means and standard deviations for the total processing time of the 17 instructional frames which contained embedded elaboration strategies are listed in Table 2 by treatment. Once prompted to press a key to proceed, students spent significantly less time viewing lesson frames which contained animated graphics as compared to instruction which contained either graphic or no graphics, $F(2,184)=45.66$, $p<.0001$. Also, and not surprisingly, students spent significantly more time viewing lesson frames which contained additional textual elaborations as compared to students who were not given additional textual support, $F(1,184)=27.29$, $p<.0001$. Apparently, students were taking the time to read all textual information presented.

A significant interaction was detected between the presence of graphics and text, $F(2,184)=3.61$, $p=.029$. Students attended longer when no graphic accompanied additional text.

Insert Table 2 About Here

DISCUSSION

The lack of main effects among the embedded elaboration conditions was surprising. Previous research has demonstrated the power of pictures over abstract words in facilitating understanding of abstract concepts. Some mental imagery researchers have posed that information is encoded into long term memory in two ways: as a mental image and as a verbal representation (Paivio, 1979). It was believed that learners would recall greater amounts of factual information as well as be more successful in solving application questions when provided with instruction which contained both graphic and textual elaboration cues than when no such cues were provided or when these cues provided only graphic or only textual information. The results from this study showed that this was not the case.

There are several possible explanations for the outcomes found in this study. First, it is possible that the students did not attend to the elaboration strategies. That is, although the elaboration strategies provided the potential for additional cognitive processing of the lesson information, the students did not make use of it. Reasons for this are debatable. An analysis of the processing latency for the lesson frames shows that students spent significantly more time viewing lesson frames which contained textually oriented elaboration strategies than similar frames which did not contain this textual information. This data implies that although the learners took longer to view frames with textually oriented information, they did not use the information in an elaborative manner. Students spent significantly less time viewing frames which contained animated graphic elaboration strategies than those with graphics or no graphics. Instead of taking additional time to think about (elaborate) or mentally reconstruct the animated sequence, the learners immediately pressed a key to trigger the presentation of the next lesson frame. When the elaboration strategy was presented in static form (graphic with or without text), learners spent a considerably longer time viewing the frame. The differences in processing time indicates that the learners were processing the elaboration strategies in different ways, but no thresholds for increased learning occurred. It should be noted that although equal amounts of learning occurred, less cognitive processing time was used by the animated graphic group, hence the potential for more efficient learning. The drawback is that the animation sequence takes more time to present than either static graphics or all-text presentations. Instead of attending to the animated instruction, students may have ignored it and spent the time reading other textual material on the screen.

Another probable explanation concerns the nature of the lesson content. The lesson material may have proved too difficult and complex for the students. This level of complexity could have prevented learners from mentally processing the elaboration strategies in the ways in which they were intended. It could have been that the embedded elaborations were instructionally too weak to affect learning, especially given the difficulty of the tasks. Since the elaboration strategies were not included in the validation process, it is difficult to make inferences about their effects.

The significant difference between near and far transfer learning is somewhat surprising. Typically, learning in near transfer situations would be expected to be greater than far transfer situations. One explanation is that the concepts were encoded meaningfully into "real life" contexts. These contexts were natural extensions of the "kicked ball" analogy used in the lesson. This rationale also helps to explain the significant interaction between learning outcome (Fact, Application) and transfer. Learners performed significantly better on factual questions in far transfer settings than on application questions in near transfer settings. The implication is that learners were actively elaborating on the ball example in simple, factually related ways and never fully processed the information in order to use it in solving application questions. If the elaboration strategies had been effective, as hypothesized, more consistent findings would have been expected.

The lack of main effects for practice was also surprising. Again, this result is probably an artifact of the task difficulty -- the lesson material was probably too complex for the age group. The practice activities were intended to provide opportunities for students to process relevant lesson content. These activities should have helped to simplify the lesson material in order to help students select relevant content. Furthermore, the activities should have encouraged organization and integration of content with prior knowledge and other lesson content. Rather, they appeared to increase the cognitive strain imposed on the students. Students probably perceived the lesson as too demanding and may have chosen to ignore potential practice benefits. Another explanation, though less likely, suggests that insufficient practice was provided. Asking students only four questions after approximately 11 computer frames may have been insufficient to activate adequate processing. No general interpretations of the usefulness of practice as an instructional technique should be inferred. The effectiveness of adjunct questions as practice strategies, under certain guidelines, has been well documented (Hamaker, 1986; Salisbury, Richards, & Klein, 1985; Wager & Wager, 1985).

Although an interaction between practice and elaboration strategy was expected, no interaction was observed. It was expected that when learners were provided good elaborative cues to facilitate appropriate imagery and verbal encoding, they would not rely on the cognitive processes activated by routine practice. Conversely, in the absence of the lesson cues believed to facilitate appropriate levels of encoding, other techniques, such as practice, would be necessary to achieve similar encoding levels. The absence of this interaction is also probably attributable to previous explanations: either the students did not attend to the lesson information appropriately, or the lesson material was too difficult.

This study has raised several questions concerning the relationship between student thought processing, instructional delivery systems, and instructional strategies. Due to an apparent confounding caused by difficult lesson content compounded by relatively ineffective lesson activities, the question of how computer animation may be used to positively affect learning remains largely unanswered. Future researchers should be careful to adequately match the complexity of materials with the maturity of the subjects. Also, replications should systematically validate the effectiveness of additional elaborations. Lessons should be designed to direct the learner to both attend to, and use, elaboration strategies appropriately.

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Table 1

Percentage Means and Standard Deviations of the Posttest Data

			Text			
			Fact		Application	
Graphic Type	Practice		Near	Far	Near	Far
Graphic	Yes	M	46.06	54.88	56.25	53.44
		SD	21.93	25.49	25.53	24.94
	No	M	45.44	50.38	40.00	43.31
		SD	25.94	20.18	25.56	23.76
Animated Graphic	Yes	M	40.56	43.38	44.38	42.75
		SD	18.91	30.18	21.28	24.05
	No	M	52.94	55.00	51.88	51.75
		SD	18.24	26.02	21.98	19.78
No Graphic	Yes	M	53.69	60.31	51.88	47.25
		SD	23.96	29.28	23.73	28.26
	No	M	50.88	53.06	44.38	54.63
		SD	24.30	29.74	25.02	26.86

			No Text			
			Fact		Application	
Graphic Type	Practice		Near	Far	Near	Far
Graphic	Yes	M	46.75	46.94	46.88	41.07
		SD	26.45	27.46	24.42	18.47
	No	M	46.75	48.69	43.13	47.25
		SD	23.48	24.45	24.42	24.28
Animated Graphic	Yes	M	52.31	56.63	49.38	55.12
		SD	28.54	29.51	22.35	23.91
	No	M	47.44	54.06	48.75	45.00
		SD	21.74	24.03	15.86	16.93
No Graphic	Yes	M	44.00	50.44	55.63	56.32
		SD	19.88	23.31	24.21	26.03
	No	M	49.50	48.63	45.00	43.32
		SD	25.34	28.08	20.66	24.44

Notes: n=16 subjects per cell.

Table 2

Mean Processing Time (in Seconds) and Standard Deviations of 17 Instructional Frames Containing Embedded Elaboration Strategies

		Text Type	
Graphic Type		Text	No Text
Graphic	M	212.65	168.74
	SD	97.14	77.57
Animated Graphic	M	83.81	44.72
	SD	94.57	46.90
No Graphic	M	246.47	134.03
	SD	123.19	62.04

Title:

Naturalistic Inquiry in Educational Technology

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Abstract

The field of educational technology developed in the 1940's out of several theoretical constructs, including perception, communication, and the psychology of learning. The basis of the primary research in educational technology was a combination of behavioral psychology and systems theory. Because of this early orientation, most research in educational technology from 1940-1980 followed experimental paradigms which attempted to show causality and/or relationships in testing the effectiveness of visual media for instruction.

More recently, researchers and scholars in educational technology have recommended widening the field to include more diversity of method and topics for study. Current researchers and educational technology doctoral students are being encouraged to investigate new questions and to consider various alternative methods of investigation. Ethnographic, descriptive, historical, and analytic methods are all being recommended to help answer questions involving how any given medium is structured to make meaning, how a medium makes its impact, and what the scope of the impact has been.

This study explores some current areas of research in educational technology and defines the non-experimental research methods which can appropriately be used to investigate these topics. If new questions are to be researched in non-traditional ways, scholars need guidance and assistance to create a new thrust of programmatic research in educational technology. The proposed continuation of this study could result in a reference guide which compiles research topics, methods, and sample studies to provide the guidance needed.

Naturalistic Inquiry in Educational Technology

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Introduction

Emerging as a separate field in the 1940's, Educational Technology drew upon theory bases from psychology, learning, and perception. The field was derived primarily from behavioral and cognitive psychology, and consequently based its seminal research on strict experimental models appropriate to the early questions and hypotheses developed. Media was tested experimentally, and found (at the time) to be effective.

In the forty years of research that followed, the same experimental paradigm predominated. New media were tested against old, characteristics of learners and specific media were compared, and relationships between learners and media were explored, all using various accepted experimental designs.

More recently, the field has broadened its definition to include instructional design, media analysis, and learner attitudes among other topics. Researchers are asking a variety of new questions, many of which would be difficult to examine using traditional experimental methods.

Background and Rationale

Currently, most of the published scholarship in educational technology has been based upon experimental and descriptive studies. The leading researchers, those who train future scholars in research methods, have only recently begun to accept a full range of research methodologies for educational technology. Consequently, educational technology journals publish few studies based upon non-experimental designs. Since reports of alternate methodologies are few, researchers in educational technology have only the models of research reports in other fields to assist them in research design and reporting.

The experimental "bias" in educational technology has been questioned by many researchers seeking to expand the areas of scholarship in the field. Becker (1977) recommended alternate methodologies to approaching educational technology research. Cochrane, et al. (1980) suggested that researchers base new areas of inquiry on "the ethnography of situations in which people use visual materials (an anthropological approach)" (p. 247). They stressed the importance of recognizing that visual learning is a cultural phenomenon and should be studied with techniques and analyses appropriate to cultural processes. Heinich (1984) in his N.I.E. funded ten year review paper encouraged researchers to engage in more "naturalistic" inquiry. "Through the use of naturalistic inquiry, I am sure we will discover important factors ... that have been ignored too long ..." (p. 84). Heinich also argued that such research should be encouraged in dissertation work and should be more disciplined and more perceptive than experimental studies.

Alternative methodologies would lead the field of educational technology to new questions, and to often ignored areas such as the impact of educational technologies on social relationships and educational institutions. Kerr (1985) suggested that methods drawn from sociology, policy sciences, and anthropology could "shed new light on problems that have traditionally been approached using psychological research methods" (p. 4). Kerr felt that asking new questions in less traditional ways was critical to the future of education.

With such recommendations for alternative methods, why has the field not adequately responded? In a symposium presentation at the 1986 Association for Educational Communication and Technology Conference, Becker, Heinich, and other researchers offered their explanations: Many strong researchers believe experimental research is vital and best; most new scholars are encouraged to design only experimental studies; alternate methodologies are fairly unfamiliar to the field and so are less acceptable to dissertation directors and journal editorial boards; and studies which employ case or ethnographic methods are more difficult to synthesize into a journal length format. This same panel recommended research using philosophical, historical, and developmental inquiry, semiotic and content analysis techniques, and several anthropological methods including case study and participant observation.

In summary, psychological, experimentally based research has formed the basis of educational technology scholarship. Recent developments in research and theory generation have resulted in recommendations for new question areas and alternate research methodologies. For several years, such suggestions have been proffered, and attempts to follow them have been reported. Symposia featuring non-experimental reports have been presented at the Conference of the Association for Educational Communications and Technology (McIsaac, Robinson, and Koetting, 1984) and elsewhere, but the methods recommended have not gained widespread use or familiarity.

There are numerous books available which detail research designs and statistical procedures. Merrian and Simpson (1984) have added to the usual texts by presenting a "full range of methodology for doing research, and by supporting points with examples from research studies done with adults in adult settings" (p. iii). It is just this sort of reference which is required by educational technology researchers to encourage and guide them to new techniques. The problem areas and theory basis of educational technology needs to be expanded, and a reference guide could provide motivation and assistance.

Purpose

This project will, when completed, have followed several steps necessary to the creation of an alternate research guide for educational technology researchers. It will, specifically:

- review the types of research recommended for future educational technology issues and concerns;

- review the non-experimental methodologies recommended by many scholars to enhance educational technology research;

- describe and discuss reported studies which have used non-experimental research techniques in educational technology;

- develop guidelines for theory, issues, and research questions appropriate to non-experimental educational technology research; and

- seek out and develop examples or models of studies utilizing alternate methods, and discuss their reportage.

Methodology

The procedures necessary to the completion of this study include the following:

1. A review of the last decade of instructional technology research would concentrate on problem areas, topics, and appropriate questions as well as research designs. As noted in the background section, several scholars have been reviewing and critiquing the educational technology research literature. Direction would be taken from their recommendations for future educational technology research.

2. A survey of materials, texts, compiled readings, etc. used by major educational technology academic programs to help students gain research skills in their field would be conducted. University programs willing to cooperate in such a compilation would be asked to respond to a survey (see Appendix 1).

3. A review of recommended alternate methodologies, including their definitions, advantages and disadvantages, and appropriate implementation. Texts such as Isaac and Michael (1981) and Merriam and Simpson (1984) would be drawn from and a bibliography for further study would be recommended.

4. A discussion of the emerging problem areas for educational technology research would be synthesized, and the appropriate methods for their investigation would be recommended.

5. Several (6-8) recent studies would be located as models' of reported non-experimental educational technology research.

With these purposes and methods in mind, a report of the first two steps in the methodology of this project follows. This is a preliminary report of a work in progress, with the expectation that others hearing or reading the report will offer ideas, suggestions, argument, or research articles to provide models for others.

Review of Research, 1976-1986

An examination of articles published in ECTJ and JID for this period was undertaken with three major focus points: topic areas, methodologies, and research questions. Also of interest were the discussion sections, especially the areas of recommended future research. These focus areas will after further review provide the answers to several questions, such as: what has been the research in educational technology? What methodologies have been chosen to answer what questions? Which topics have attracted the most research, and what areas have been recommended for more investigation? What conclusions can be drawn about the use of experimental and "alternate" methods of research in educational technology?

First to emerge were subject areas which allowed the organization of this compilation of our recent research history. The following areas emerged, as they have been defined and exemplified.

1. Visual Literacy - includes studies on visual cuing strategies, physiological effect of cuing (e.g. scanning behavior, eye movement); various pictorial attributes, effects of visualization, and individual differences variables (picture-style preferences, picture-interpretation behavior of children). Example of study: Responsiveness of Nigerian students to pictorial depth cues.

2. Instructional Development - includes studies which addressed and/or have implications for instructional media design/development; studies which developed models for message design, presentation, production and instructional methods/approaches. Example: Supplementing traditional instruction with objective-based instructional development.

3. Computers - CAI, CBI, computers in education and industry. Example: Computer-based foreign language instruction: Improving student attitudes.

4. Learning Strategies - studies on mnemonic strategies, imagery, and other learning or cognitive strategies such as rote and networking; visual and verbal information processing. Example: Information processing from screen media: a psycholinguistic approach.

5. Learner Characteristics - types of learners, learner preferences, motivation, orientation, abilities, attitudes, etc. Example: Interaction between student achievement orientation, locus of control, and two methods of college instruction.

6. Media Utilization/Attributes - media symbol systems, coding, media use in education, media selection. Example: A survey of school teachers' utilization of media.

Certainly there may be some other possible topic areas, or alternate definitions; however, those chosen were considered valid and helpful for our discussion.

Tables 1, 2, and 3 review the number of articles reviewed, by topic and by methodology. (insert tables about here). As shown, the most common topics were computers in education, instructional development, visual literacy, media attributes/utilization,and learning strategies. As expected, experimental research was by far the most prevalent, with any of the other methods cited only rarely.

Of non-experimental methods, the most often used was survey, and surveys were most often found necessary in the topic area of computers. Perhaps with the introduction of a fairly new technology, surveys were necessary to determine use patterns and adoption practices. The topic area that was investigated using the widest range of methods was instructional development. While most research reports cited experimental method, case/field study, survey, and descriptive methods were also used. The delphi technique, naturalistic methods, and evaluation studies as well as theory development were also reported.

Overall, the review of research topics and methodologies provided few surprises. Experimental methods were used most often, and were reported in all topic areas except mass media and training. "Qualitative" research methods were much more rare. Descriptive, historical and philosophic approaches, the more commonly accepted methods, accounted for only 12 research reports. Case/field study, delphi, and naturalistic methods were cited in only 18 studies. The experimental models were obviously found to be the most useful and viable for the last 10 years.

Survey Results

The survey was introduced at the annual P.I.D.T. conference in Bloomington, Indiana, and the mailing list for the meeting was used for initial selection of respondents. The A.E.C.T. Human Resources directory was also consulted, as was the Educational Media Yearbook. Of the almost 60 university programs offering master's and doctoral degrees, 30 were selected for participation in this survey. In addition, a letter of intent and the survey were published in the R.T.D. Newsletter, with an open request for information from other programs.

Of this representative group, twenty surveys were returned, 19 from university programs and one from a corporate training center. Responses herein discussed were from these programs: Arizona State, Brigham Young, Colorado-Denver, Florida State, Indiana, Iowa State, Kent State, Manitoba, Minnesota, Oklahoma, Ohio State, Pennsylvania State, Texas A & M , and Washington, among others.

The six questions on the survey were intended to elicit information about the research course requirements in the program, the research methods taught, the books used, the expectations of the department (if any) as to type of research encouraged, and the current topics being researched by faculty and students at the institution. A copy of the survey is included as Appendix 1. The survey was useful in a number of ways. First, it served to call attention to this area of interest, non-experimental research, and discover what interest and expertise other faculty have in the area. Second, it provided a list of texts currently used or recommended for teaching research skills. Third, it revealed that, while encouraging students to conduct research using "whatever method appropriate to their question", most programs responded negatively to current research being done using non-experimental methods. There were several responses that declared interest in this topic, but very few that displayed much expertise or practice with the "alternate" methods of conducting research or even posing questions.

Specifically, then, the survey provided the following responses. All programs responding had required research courses for doctoral students, and many had such courses for master's students as well. Most of these courses were taught by faculty other than instructional systems faculty, usually in the educational psychology program. Consequently, respondents' familiarity with the course content was not as instructor nor designer of these courses. Eight programs had their own course or courses in instructional systems research, usually seminars for doctoral students. Texts required for these basic research courses included those by Kerlinger, Borg and Gall, McMillan and Schumacher, Dwyer, Best, and Tuckman.

Of the programs responding to question 3., only eight had a separate course or unit highlighting non-experimental research methods. Texts used in these courses included those by Bogdan and Bikleu, Miles and Haberman, Spradley, Patton, Willis, and Guba and Lincoln. These texts consider qualitative research in education, naturalistic inquiry, and ethnographic methods of research.

Almost all programs responded that students are encouraged to conduct research appropriate to their question, but ten programs encourage experimental methods first, and seven programs responded that they encourage "alternate" methods. Many programs reported that students are advised to seek out courses in other university departments which could assist them in gaining skills in non-experimental research, such as anthropology or sociology. Only one program had a full course in "alternate" methods, a seminar at Florida State. Other programs such as the one at N.I.U. reported that students in instructional systems seminars are provided materials and readings in non-experimental research since the required educational psychology research courses teach them experimental methods and statistics.

Several programs listed current research topics being investigated in both experimental and non-experimental studies. These included:

experimental: videodisc instruction
persuasion and media
model and theory building
expert systems
effects of CAI
computerized testing

non-experimental: use of distance technology
effects of microcomputers on student interaction
importance of university film and video collections
reactions to high school classes taught by satellite
computers in higher education
television production
dissemination of technology
product development and evaluation, techniques and model development.

Methodologies for these non-experimental studies included survey, delphi technique, meta-analysis, case study, participant observation, literary criticism, film criticism,interview, and multiple qualitative methods. The list was a substantial enough one to expect that some of these studies would derive information reportable at conferences and publishable in future journal volumes. From these responses it could be summarized that the interest in "alternate" methodologies is substantial and possibly increasing. Several respondents remarked that faculty or students were interested but unfamiliar with such research. "I think the more naturalistic approaches are much more suited for instructional technology than the harder, quantitative ones," is a quotation that characterizes such interested respondents. Overall, the survey provided the expected information: lists of courses, one syllabus, several text recommendations, and topic areas currently being investigated both experimentally and non-experimentally. Interest in the "alternate" methodologies was also evident from the responses.

With sections one and two of the methodology of this project having been discussed, the question is, what next? Obviously, a more thorough review of the currently reported topics and methodologies will reveal the questions and the results of the research reviewed (1976-1986). This review will provide a more detailed look at the current state of research in instructional technology: the purpose, the results and the need for future research.

Also, this ten year review will summarize the recommendations made in the several "review" or "critique" articles which have critically analyzed the research over the last ten years and made suggestions for future topic areas and methodologies. These articles should prove useful for the development of a list of topic areas and emphases considered appropriate for the future.

In addition to the above review of research, a review of the topics and methodologies, purposes, results, and recommendations will be completed for the last several years using Dissertation Abstracts and the R.T.D. Proceedings as primary sources. When these steps are completed, a fairly total picture of the current research should be drawn. Topic areas, methods, questions, results, and future recommendations when compiled will provide a clear picture of the current state of research in instructional technology. The consideration of future topics and methods can be then situated in a full review of the recent past.

Another, more controversial step also remains in this project. A discussion and definition of available "alternate" methods of research must also include the question of the prevailing paradigm under which our research is conducted. There is a large difference between recommending surveys or interviews or even observation and recommending that the field consider a paradigm other than the scientific paradigm now guiding our research. Several presentations at our A.E.C.T. conferences have made clear the need for the field to grow in new directions; a growth made possible only by the posing of essential questions in new frameworks. A new science model has been recommended, as has an artistic model (Eisner) or a semiotic model (Barthes), among others. This question of paradigm shift must be discussed and resolved as we move into the 1990's and our research moves into new areas.

The non-scientific paradigm can be productively used to develop new areas and methods of research in instructional technology. Methods such as linguistic analysis, phenomenology, case study, grounded theory, action, participation, observation, and simulation can all be "borrowed" from other, well-defined and developed disciplines and applied to our field. These methods are not considered "soft" in other fields, and have as their advantage the development of breadth and depth of research not possible in the experimental methods.

The survey and research review both showed an increased interest in non-experimental research. Less clear is the acceptance of a true paradigm shift in instructional technology research. A different type of question could and should be posed, according to many in our field. This project proposes, when finished, to discuss both the paradigm shift, the "alternate" methods it would necessitate, and the various data gathering techniques available to researchers, regardless of the paradigm being used. It is hoped that through the completion of this project, enough evidence of quality research methodologies, topics, and questions will be derived to provide future researchers, and the professors who teach them, with helpful guidelines to alternative research in our field.

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Table I

Years	Number of Studies Reviewed												
	Visual Literacy	Instruc. Development	Computers	Film	TV	Video	Learner Charac.	Learning Strategies	Media Util./ Attributes	Research in Ed Tech	Mass Media	Ed. Tech. as Field	Training
1977-1982	25	31	-	3	5	-	9	13	12	2	1	-	1
1983-1987	6	23	41	-	-	4	6	11	15	1	-	3	3
Total	31	36	41	3	5	4	15	24	27	3	1	3	4

Table II

Research Methodologies Employed

Areas	Historical	Descriptive	Survey	Case/Field	Causal-Comparative	Quasi-Experim.	Exploratory/Pilot	Experimental
Visual Literacy					1		3	21
Instructional Development	1	4	5	7				24
Computers		1	14	4		1		16
Film								3
TV	1							5
Video							1	3
Learner Characteristics			1			1	2	11
Learning Strategies		3	1					19
Media Utilization, Attributes			3		1		1	21
Research in Educ. Tech.			1			1		
Mass Media			1					
Educ. Tech. as a Field			1					
Training			2	1				

Table III

Research Methodologies Employed

Areas	Correlational (Factor Analytic)	Delphi Technique	Meta-Analysis	Evaluation	Theory Development	Naturalistic	Bibliometric Analysis	Philosophical
Visual Literacy	1		1		3			
Instructional Development		2	1	2	2	2		
Computers				2		1	1	
Film				1				
TV				1	1	1		
Video					1			
Learner Characteristics								
Learning Strategies								
Media Utilization, Attributes		1	1					
Research in Educ. Tech.					1			
Mass Media					1			
Educ. Tech. as a Field								2
Training				1				

Appendix I

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N.I.U.

Name ______________________________

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Naturalistic Inquiry in Educational Technology

Recently, researchers and scholars in educational technology have recommended widening the field to include more diversity of method and topics for study. We are being encouraged to investigate new questions and to consider various alternative methods of investigation. Ethnographic, descriptive, historical, and analytic methods are all being recommended to help answer questions involving how any given medium is structured to make meaning, how a medium makes its impact, and what the scope of the impact has been. If new questions are to be researched in non-traditional ways, scholars need guidance and assistance to create a new thrust of programmatic research in educational technology. My work will result in a reference guide which compiles research topics, methods, and sample studies to provide the guidance needed.

This proposed project (full proposal available upon request) requires information from the varied programs around the country teaching research skills. Your help is greatly appreciated.

Please answer for your program, to the best of your knowledge.

1. Is there a separate course or unit which discusses research methods? Name of course? Enrollment?

2. Does this course survey several research methods? What text(s) are required? Recommended?

3. Is a separate course or unit taught which highlights non-experimental research methods? Which methods are included? What text(s) are used? Who teaches this course?

4. Are masters or doctoral students encouraged to investigate questions experimentally? Are "alternate" inquiry methods encouraged?

5. Have any students recently completed studies which employed alternate research methods? Topics explored? Methods chosen?

6. Please list the research topic(s) or area(s) currently being explored by yourself and/or your students. Include research methodology utilized.

As some of you are aware, I am undertaking a study on research methodologies in educational technology. My goal is to create a reference text which compiles research topics, methods, and sample studies for scholars who may want to use non-traditional research methods in their investigation of new questions in educational technology. In this regard I am conducting a survey of academic programs that teach research skills. If you have not already participated, please provide the requested information pertaining to your program (survey follows). Your help in this survey is highly appreciated.

Please return the survey to me at the address below. Thank you for your professional cooperation.

Sincerely,

Rhonda

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ljb

Enclosure

Title:

Text Density and Learner-Control as Design Variables with CBI and Print Media

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Text Density and Learner-Control as Design Variables with CBI and Print Media

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Paper presented AECT Annual Conference, New Orleans, LA, Jan. 14-19, 1988

Text Density and Learner Control as Design Variables With CBI and Print Media

Instructional designers frequently ignore the unique properties of computer-based instruction (CBI) by creating materials using the same design formats and teaching strategies traditionally incorporated in print lessons (Bork, 1985; Burke, 1982). One important difference between the two media lies in the constraints that CBI imposes on the display of instructional text (Grabinger, 1983; Hartley, 1985; 1987; Lancaster & Warner, 1985; Richardson, 1980). Specifically, computer text offers considerably less flexibility than print by: (a) limiting the visible display to one page at a time, (b) making backward paging for review purposes more difficult, (c) limiting the size of the page layout to about 24 lines and 40-80 characters, and (d) offering limited cues regarding lesson length.

Recognizing these properties, instructional designers generally advocate formats that minimize clutter and maximize "white space" in the display area (Allessi & Trollip, 1985; Bork, 1985; Burke, 1982; Caldwell, 1980; Heines, 1984; Tullis, 1981). One popular system for spacing text is "chunking" (Bassett, 1985; Grabinger, 1983), which involves separating sentences into meaningful thought units with blank spaces surrounding each. Chunking and similar methods, however, have failed to show clear advantages under either print or CBI presentations (cf, Bassett, 1985; Carver, 1970; Feibel, 1984; Gerrell & Mason, 1983; Hartley, 1987; O'Shea & Sindelar, 1983). A possible limitation is that they leave lesson content unaltered while presenting it in an unfamiliar format.

The main interest in the present research was varying lesson content in accord with attributes of the presentation media employed. Of specific concern was the level of "richness" or detail provided in instructional text, an attribute we will label text "density level." In earlier research with print material, Reder and Anderson (1980; 1982) compared complete chapters from college textbooks with summaries of main points on both direct and indirect questions. In 10 separate studies, summaries were found to be comparable or superior for learning to the original text. The authors concluded that summaries may help students to isolate central ideas without the distraction of having to attend to unimportant details. Similar to the Reder and Anderson (1980) study, the present conception of text density level concerned such attributes as length of materials (number of words used), redundancy of explanations, and depth of contextual support for important concepts. This construct resembles what reading researchers have labeled the "microstructure" of text (Davison & Kantor, 1982), as contrasted with "macrostructure" which concerns how information is organized and elaborated through comparison of examples, nonexamples, and concept categories (Di Vesta & Finke, 1985; Frayer, Fredrich, & Klausmier, 1969; Moes et al., 1984; Reder, Charney, & Morgan, 1986). An example of a low-density frame and a parallel high-density frame from the present instructionl materials is presented in Figure 1. Note that the low-density version contains the same information as the conventional version but eliminates details and nonessential words. The result is approximately a 50% reduction in both number of words and screen area required. One hypothesis in the present study was that such low-density narrative would promote better learning and more favorable attitudes on CBI lessons by reduiig reading and cognitive processing demands of screen displays.

Insert Figure 1 about here

A second research interest was the nature and effects of learner preferences for different density levels in print and CBI modes. Although "learner-control" strategies that allow students to self-determine instructional conditions have shown positive results in some studies (Judd, Bunderson, & Bessent, 1970), recent findings have more often been negative (Carrier, Davidson, & Williams, 1985; Carrier & Sales, 1985; Fisher, Blackwell, Garcia, & Greene, 1975; Lahey & Crawford, 1976; Ross & Rakow, 1981; Tennyson, 1980). Studies of aptitude-treatment interaction (ATI) effects further suggest that the less the student's prior knowledge, the less effective learner-control tends to be (Carrier & Sales, 1985; Fisher et al., 1975; Gay, 1986; Hannafin, 1984; Ross & Rakow, 1981; 1982; Tennyson, 1980). To extend this research, we explored the viability of allowing learners to make selections of text density level, which unlike the variables of task length, quantity, and difficulty emphasized in previous studies, represents a contextual rather than primary lesson property. Low-density computer text was expected to be a more popular choice than the high-density versions due to the relative difficulty of reading text from CRT screens. These questions were examined by crossing two presentation modes (computer vs. print) with three text density conditions (high, low, and learner control). Dependent variables were different types of learning achievement, lesson completion time, attitudes, and learning efficiency.

Method

Subjects and Design

Subjects were 48 undergraduate teacher education majors enrolled in a beginning instructional technology course. They were assigned at random to six treatment groups in which learning materials were presented in either of two modes (computer or print) under one of three text density-level conditions (high, low, learner control).

Materials

Profile data form. A brief questionnaire was used to determine subjects' attitudes toward mathematics and CBI. Ratings were recorded on five-point Likert-type scales, with "5" representing the most positive reaction.

Instructional Unit. The learning material was an introductory unit on central tendency. The unit, which was organized into five

Instructional Unit. The learning material was an introductory unit on central tendency. The unit, which was organized into five sections, emphasized the teaching of facts and conceptual information that students would need to recall to solve and interpret problems. A conventional (high-density) print version of the lesson was initially prepared. Total length was 18 pages and 2,123 words. Within each section the basic instructional orientation involved defining the concept or main idea and then illustrating its application with several context-based numerical examples.

Following Reder and Anderson's procedure, low-density text was systematically generated from the conventional text by (a) first defining a set of general rules for shortening the material, (b) having at least two people discuss the rules and rewrite the materials accordingly, and (c) reviewing the material and making changes until consensus was achieved that all criteria were satisfied. Specific rules employed were:

1. Reduce sentences to their main ideas.
    a. Remove any unnecessary modifiers, articles, or phrases.
    b. Split complex sentences into single phrases.
2. Use outline form instead of paragraph form where appropriate.
3. Delete sentences that summarize or amplify without presenting new information.
4. Present information in "frames" containing limited amounts of new information, as in programmed instruction.

The completed low-density lesson consisted of 1,189 words, a 56% savings relative to the high-density version, and 15 pages, a 17% savings (see samples in Figure 1). CBI versions of the high- and low-density lessons were prepared directly from the print materials. Word counts for corresponding low- and high-density versions were identical across print and computer modes. Due to the much smaller display area of the computer screen, it was not possible or (considered desirable) to duplicate the print page formats. Computer frames were thus designed independently, using what were subjectively decided to be the most appropriate screen layouts for presenting the material. Each screen provided both back- and forward-paging options. The final versions of the low- and high-density CBI lessons consisted of 49 and 66 frames, respectively.

Attitude survey. Attitude items consisted of statements about the learning experience to which subjects indicated levels of agreement or disagreement on a 5-point Likert-type scale (e.g., 1 = "strongly disagree," 5 = "strongly agree"). Abbreviated descriptions of the six statements comprising the survey are: "Lesson moved quickly," "Material was interesting," "Was easy to learn," "Explanation was sufficient," "Text layout was easy to read," and "Prefer this method over lecture." Internal consistency reliability for the survey, computed by Cronbach's alpha formula, was r =.63 (n = 48).

Achievement posttest. The achievement posttest (print format) consisted of four sections designed to assess different types of learning outcomes. The first two sections were considered knowledge subtests, since each assessed recognition or recall of information exactly as it appeared in the text. The knowledge-1 subtest ("definitions") contained 17 multiple-choice items, each consisting of a statement describing one, all, or none of the three central tendency measures (mean, mode, or median). Those that described central tendency measures included the exact key words contained in both low- and high-density narratives. The knowledge-2 subtest ("distributions") contained eight questions concerning the effects of symmetrical and skewed distributions on the placement and interpretation of the mean and the median. On four of the items subjects were asked to write a brief rationale for their answers. The distributions shown on all items were exact replications of examples that appeared in the lesson.

The calculation subtest contained five problems requiring computation of different central tendency measures from new data not used in lesson examples. The transfer subtest consisted of 13 items that involved interpreting how central tendency would vary with changes in distributions or individual scores. Items of this type were not included in the lesson, nor were the underlying principles needed to answer those items explicitly stated. They were thus considered measures of transfer (or conceptual) learning.

Scoring rules on objective items and calculation problems awarded one point for a correct answer. On interpretative items one point was awarded for a correct answer and an additional point for a correct explanation. Internal consistency reliabilities were computed by means of the KR-20 formula for subtests with dichotomous item scores and by Cronbach's alpha formula for the remainder. A summary of resultant reliability values along with subtest lengths and maximum points is as follows: knowledge-1 (17 items, 17 points, r =.60), knowledge-2 (8 items, 12 points, r =.57), calculation (5 items, 5 points, r =.67) and transfer (13 items, 20 points, r =.84).

Procedure

Subjects completed the profile data form during a regular class meeting, at which time they signed up to receive the learning task the following week. Typically from 3-15 subjects attended an individual session. Two similar classrooms were used, one for the print condition and the other for the CBI condition. The latter classroom contained 12 Apple IIe computers with monochrome screens, either single or double disk drives, and from 64K to 128K of memory. Proctors began the session with instructions for completing the task. Instructions for all treatments indicated that (a) the five units were to be studied at one's own pace, (b) turning back to reread preceding pages (frames) was permitted if desired, and (c) a posttest would be given following the learning task. Subjects in the learner-control treatment received additional instructions indicating that depending on how much explanation they desired, they could choose between "long" and "short" presentations on each section. To help the subject make a decision for the first section, actual samples of parallel low- and high-density pages were shown. In the computer condition, subjects pressed a key to indicate their preferences, following which the appropriate high- or low-density version of the unit was presented. In the print condition, preferences were indicated orally to the proctor who then distributed appropriate materials. The same density selection procedures were repeated at the beginning of each of the remaining four sections. After subjects completed the last section, their finish times were recorded and the attitude survey was administered followed by the posttest.

Results

The basic statistical design was a 2(presentation mode) x 3(density condition) factorial. An alpha level of .05 was used to judge significance. Treatment means and standard deviations on major dependent variables are summarized in Table 1.

Insert Table 1 about here

Initial 2 x 3 ANOVAs were conducted on responses to the profile data survey to judge the equivalence of treatment groups prior to the administration of experimental tasks. No significant main effects or interactions were found on any of the items.

Learner-Control Selections

Preliminary analyses were made of density-level selections by learner-control subjects. Results for CBI and print groups combined (n = 16) showed that low-density and high-density materials were selected with equal frequency (both M's = 2.5) across the five sections. Low-density material, however, was selected an average of 3.75 times (and high-density 1.25 times) by print subjects, whereas the exact opposite pattern occurred for the CBI group (low-density M = 1.25; high-density M = 3.75). The differential showing greater *low-density* preferences by the print group was significant, $t(14) = 2.57$, $p < .05$.

Achievement Results

Analysis of scores on the knowledge-1 subtest ("definitions") showed a significant main effect of presentation mode, F (1, 42) = 4.48, $p < .05$. Subjects in the print condition (M = 13.1; 77% correct) scored higher than those in the CBI condition (M = 11.6; 68% correct). Neither the density level effect nor the interaction was significant.

The ANOVA performed on calculation subtest scores, showed the main effect of presentation mode, F (1, 47) = 10.08, $p < .02$, to be the only significant outcome. As on the knowledge-1 test, the print group (M = 4.0; 80% correct) surpassed the computer group (M = 3.1; 62% correct). No significant main or interaction effects were found on either the knowledge-2 or transfer subtests.

Lesson Completion Time and Learning Efficiency

The analysis of lesson completion time yielded a highly significant presentation mode main effect, $\underline{F}$ (1, 42) = 26.65, $\underline{p}$ < .001; and a marginally significant density-level main effect, $\underline{F}$ (2, 42) = 2.53, $\underline{p}$ < .10. The presentation mode effect was due to print subjects' taking significantly less time ($\underline{M}$ = 18.0 min.) to complete the lesson than did CBI subjects ($\underline{M}$ = 32.3 min.). The ordering of density-level groups was as expected, with low-density lowest ($\underline{M}$ = 20.8 min.), learner-control next ($\underline{M}$ = 26.9 min.), and high-density highest ($\underline{M}$ = 27.8 min.). The specific comparison between high- and low-density levels is attentuated, however, by the inclusion of the learner-control treatment which represented a mixture of the two variations. When the learner-control treatment was excluded from the analysis, the time savings for the low-density groups reached significance, $\underline{F}$ (1, 427) = 4.30, $\underline{p}$ < .05.

A desired outcome of adaptive instructional strategies is to improve learning efficiency, as measured by the level of achievement attained per instructional time allocated. Accordingly, as in several previous studies on adaptive instruction (Ross & Rakow, 1981; Tennyson & Rothen, 1977), treatments were compared on efficiency scores, computed as the ratio of posttest total score divided by lesson completion time. The ANOVA results showed the instructional mode main effect to be the only significant source of variance. Efficiency means for these comparisons were 2.15 for print versus 1.21 for CBI.

Attitude Results

Given that each attitude item dealt with a different property of the lesson, analyses were conducted to examine separate outcomes on each. No effects were obtained on Items 2 ("interesting"), 3 ("easy to learn"), or 5 ("readable layout"). On Item 1 ("lesson moved quickly"), the presentation mode x density level interaction was significant, $\underline{F}$ (1, 42) = 5.15, $\underline{p}$ < .05; and the presentation mode main effect approached significance ($\underline{p}$ < .10). In follow-up analyses, using the Tukey HSD procedure, the only difference was found within the high-density condition: print subjects ($\underline{M}$ = 4.25) gave significantly higher ratings ($\underline{p}$ < .05) than CBI subjects ($\underline{M}$ = 2.50). On Item 4 ("amount of explanation was sufficient") the two-way interaction was again significant, F(2, 42) = 4.22, $\underline{p}$ < .05. Comparisons between presentation modes showed significant variation only within the low-density condition: CBI subjects ($\underline{M}$ = 4.50) rated the materials higher ($\underline{p}$ < .05) in sufficiency than did print subjects ($\underline{M}$ = 3.23). The only other significant finding was the presentation mode main effect on Item 6 ("prefer method over lecture"), F(1, 42) = 5.28, $\underline{p}$ < .05. CBI subjects ($\underline{M}$ = 3.75) were more positive about the teaching method received than were print subjects ($\underline{M}$ = 2.96).

Discussion

In contrast to Reder and Anderson's (1980; 1982) subjects who were tested exclusively on factual recognition (via treefalse questions), the present sample was administered a variety of achievement measures designed to assess factual knowledge, problem solving, and transfer. The absence of any evidence favoring the high-density text is consistent with the view, as theorized in hierarchical models of text structure (Meyer, 1975), that retrieval of main ideas is not necesszrily facilitated by providing additional details (or elaborations) in the text. However, if students are to develop good reading and writing skills, frequent exposure to elaborated and structurally sophisticated text styles seems essential. With this qualification in mind, instructional designers might consider selective uses of low-density narrative to reduce lesson length and completion time, in situations (such as CBI) where it is costly or difficult to display long segments of text.

Overall, the experimental findings were not supportive of CBI relative to print as a delivery medium for the present statistics lesson. In attempting to interpret this result one might consider Clark's (1983) suggestion that it is not media per se that affect learning, but the instructional strategies that the given media employ (also see Clark, 1984; 1985; Solomon & Gardner, 1985). Clark (1983) reinforces this point through the analogy that, "media are mere vehicles that deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes changes in our nutrition" (p. 45). From this perspective, the consistency of outcomes across media studies would seem more validly interpreted on the basis of the instructional strategies used and the content taught rather than on how the lesson was delivered. It thus becomes important to recognize the present lesson's dependency on mostly narrative descriptions of rules and operations and allowance of self-pacing. These instructional features remained constant regardless of mode, but print offered the possible advantage of representing the text in a more readable and accessible form. Further, most subjects in the present study were unfamiliar with and probably somewhat threatened by both the statistical subject matter and learning from CBI. Given the newness of CBI for the present sample and its reputation as a "smart" medium (see Clark, 1984; Salomon & Gardner, 1986), it would seem likely that many subjects would naturally perceive it as more difficult or challenging than print. Such perceptions, if they occurred, would be consistent with the high degree of task persistence demonstrated by CBI subjects in their very deliberate pacing rates and preferences for high-density over low-density material under learner control.

Attitude results also suggested differences in how the two media were perceived. Subjects' generally favorable reactions to CBI were conveyed in their giving it higher ratings than print as a desired alternative to lecture. Interestingly, neither mode was favored on "clarity" or "readability" dimensions, but CBI subjects rated the lesson as slower moving than did print subjects, especially when high density material was used. CBI subjects also rated low-density material higher in sufficiency than did print subjects, even though both groups received the exact same content. Despite these perceptions, learner-control selections by the CBI group favored high density materials 75% of the time, compared to oly a 25% selection rate under print. The overall impression is of a less confident and more conservative attitude of the CBI group, which generally worked as a disadvantage for achievement and learning efficiency.

Seemingly, with students more experienced with CBI, little difference would have occurred between media. Further, potential bias was introduced by the decision to design realistic rather than parallel CBI and print displays to increase the external validity of density comparisons within each medium. In both applications use of low-density text was supported as a design strategy for expository lessons. The spatial limitations of electronic displays obviously makes low-density formats especially appealing for CBI.

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Table 1

Treatment Means and Standard Deviations on Major Dependent Measures

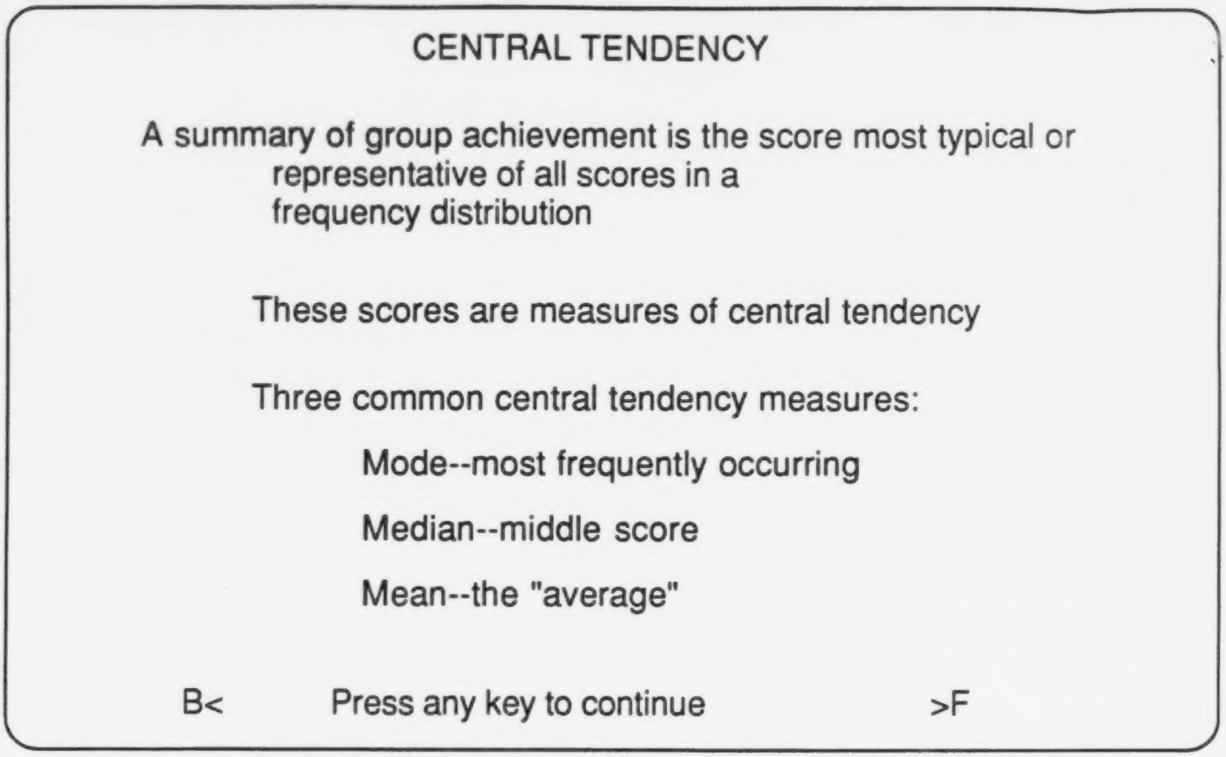
Measure	Print				Computer			
	L-Density	H-Density	L-Control	All	L-Density	H-Density	L-Control	All
Knowledge-1 (17)[a]								
M	12.6	13.1	13.6	13.1	12.1	11.0	11.6	11.6
SD	1.8	1.5	2.0	1.8	3.4	3.0	2.8	3.0
Knowledge-2 (4)								
M	7.4	7.3	9.0	7.9	8.1	7.1	7.5	7.6
SD	2.7	4.5	2.9	3.4	3.2	3.3	3.2	3.1
Calculation (5)								
M	3.8	3.8	4.5	4.0	3.6	2.4	3.3	3.1
SD	0.9	1.5	0.8	1.1	1.5	1.7	1.3	1.5
Transfer (20)								
M	10.6	10.9	14.3	11.9	10.5	9.1	9.8	9.8
SD	5.7	4.3	3.9	4.8	6.4	7.3	5.1	6.1
Attitude Total (30)								
M	20.0	21.7	21.5	21.1	21.6	20.6	21.9	21.4
SD	4.9	4.3	3.0	4.0	2.9	2.8	2.7	2.8
Study Time (Min.)								
M	17.4	18.4	18.4	18.0	24.3	37.3	35.5	32.3
SD	3.7	3.1	3.8	3.4	8.4	16.4	13.1	13.8

[a] Numbers in parentheses following measures indicate maximum scores.

Figure Caption

Figure 1. Sample low-density and high-density frames from CBI lesson.

Low-density sample



CENTRAL TENDENCY

A summary of group achievement is the score most typical or representative of all scores in a frequency distribution

These scores are measures of central tendency

Three common central tendency measures:

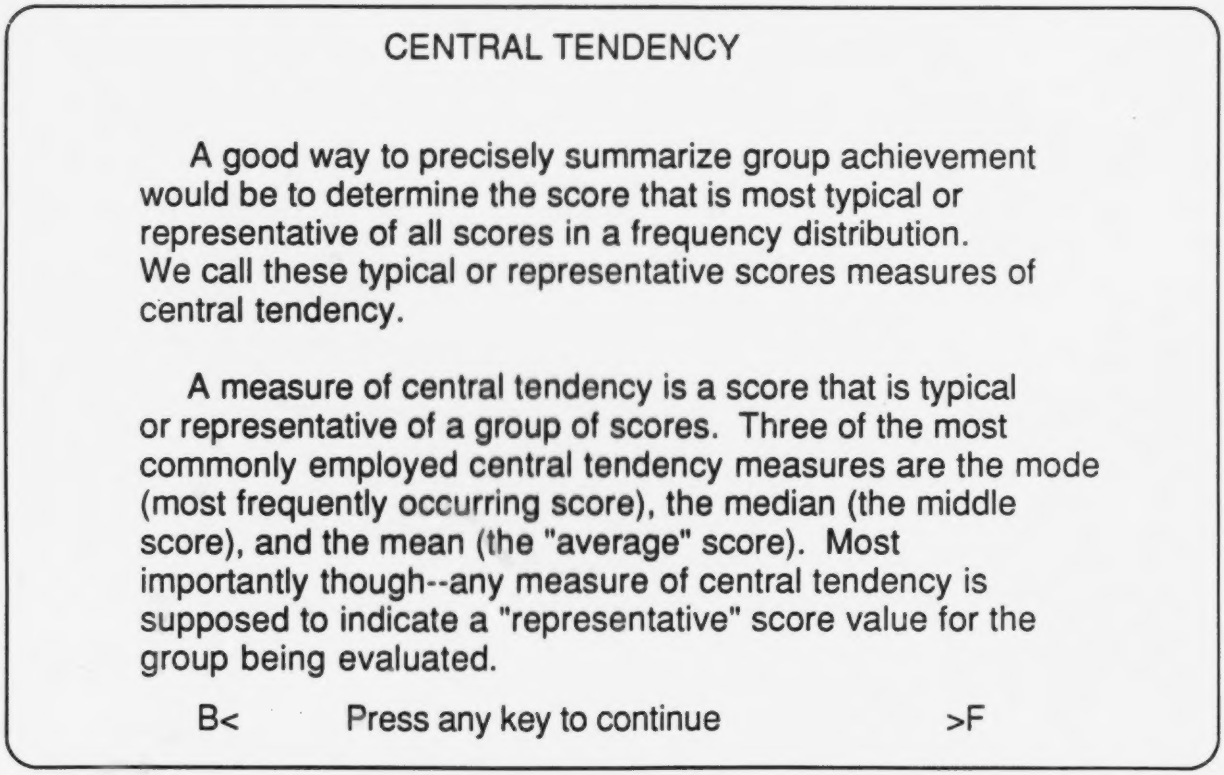
Mode--most frequently occurring

Median--middle score

Mean--the "average"

B< Press any key to continue >F

High-density sample



CENTRAL TENDENCY

A good way to precisely summarize group achievement would be to determine the score that is most typical or representative of all scores in a frequency distribution. We call these typical or representative scores measures of central tendency.

A measure of central tendency is a score that is typical or representative of a group of scores. Three of the most commonly employed central tendency measures are the mode (most frequently occurring score), the median (the middle score), and the mean (the "average" score). Most importantly though--any measure of central tendency is supposed to indicate a "representative" score value for the group being evaluated.

B< Press any key to continue >F

Title:

A Comparison of Instructional Intervention Strategies with Newly Amplified Hearing-Impaired Adults

Author:

Sharon E. Smaldino
Joseph J. Smaldino

A Comparison of Instructional Intervention Strategies with Newly Amplified Hearing-Impaired Adults

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A Comparison of Instructional Intervention Strategies with Newly Amplified Hearing-Impaired Adults

Introduction

Aural rehabilitation is an area of audiology that has received the least attention and research (Alpiner, 1982a). There have been major improvements in the technological aspects of audiology, but the remediation process has remained virtually unchanged for decades. There have been efforts to identify effective and efficient means of improving benefit from hearing aids (Walden, Prosek, Montgomery, Scherr, and Jones, 1977; Walden, Erdman, Montogmery, Schwartz, and Prosek, 1981; Alpiner, 1982a). None, however, have identified an approach that seems to be consistently effective.

The lack of advancements in the rehabilitation of the hearing-impaired adult is of serious consequence. As the population ages, more adults are being diagnosed and fitted with hearing aids, but significant numbers become frustrated and stop wearing their hearing aids during the first few weeks (Alpiner, 1982a). These individuals need to be offered opportunities to adjust to and function with their new hearing aid easily and efficiently.

In many of the studies of amplification adjustment, individual differences were often cited as the reasons why any one particular training technique or combination of techniques were ineffective in decreasing the perception of hearing handicap by adults (Bode & Oyer, 1970; Walden et al., 1981). The perception of hearing handicap can best be defined as the hearing-impaired person's feelings about how well or poorly he/she functions in listening situations.

It may be that the differences among hearing-impaired adults can be explained by differences in their learning styles. Cronbach and Snow (1977) have suggested that the manner in which individuals approach information processing situations generally takes the form of patterns established early in life. These patterns or strategies are termed cognitive style, which may be important to consider when determining their individual learning styles (Garger & Guild, 1984). Research is generally in agreement that the more personalized the instruction, the faster and better the possibility of accomplishment of a given task by the individual (Murray, 1979; Fourier, 1984).

One approach to personalizing instruction and helping the individual understand the manner in which information is processed is termed cognitive style disclosure. Evidence in the literature suggests that this approach is very effective in community college settings (Hill & Nunney, 1971; Fourier, 1984; Niles & Mustachio, 1978). It is possible that the cognitive style disclosure approach might be beneficial in the aural rehabilitation of newly amplified hearing-impaired adults.

Summary of Research Project

The purpose of this study as to identify aural rehabilitation training strategies that would significantly reduce the feeling of hearing handicap by first-time hearing aid users. An aural rehabilitation program was used composed of a brief introduction to hearing aids and the skills associated with using a hearing aid (Traynor & Smaldino, 1986) (Appendix A). This approach to aural rehabilitation, alone or in combination with information about cognitive learning style, as presented to first-time users of hearing aids. Cognitive style information was also presented to a group of new hearing aid users without including any additional components of the aural rehabilitation program.

The study involved assessing listening performance in situations both before and one month following the wearing of the new hearing aid. The prefitting inventory was used to measure the client's perception of hearing handicap. Also included was an assessment of individual cognitive learning styles.

A further question investigated in this study was to determine if there was a correlation between the subscales of the cognitive learning style inventory and the subscales of the hearing handicap inventory. This was a preliminary effort to see if there was any relationship between the presence or absence of a particular cognitive learning style and elements of a hearing handicap.

Forty newly amplified hearing-impaired adults ranging in age from 30 to 90 served as subjects in this study. They had not worn a hearing aid prior to participating in this study. Each participant completed the revised Albany Learning Style Inventory (Bosco, 1983) and the revised Hearing Performance Inventory (Lamb, Owens, Schubert, and Giolas, 1979) prior to their random assignment to a treatment group. There were four groups: Control (CG), Cognitive Style Disclosure (CSG), Aural Rehabilitation (ARG), and Cognitive Style Disclosure/Aural Rehabilitation (CS/ARG). Each subject received one of these treatments during a four-week trial period. At the end of the four-week trial, each participant completed the Hearing Performance Inventory again.

The statistical procedure used for data analysis was a two-way analysis of variance. A correlation matrix was developed to investigate the relationships between the subscales of the two inventories.

Conclusions of the Study

Perception of Hearing Handicap

The first three experimental questions were designed to identify possible alternative training procedures in the rehabilitation of newly amplified hearing impaired adults. The difference between the pretest and posttest score of the Hearing Performance Inventory were used to calculate means for the four groups studied (Table 1). The result of the two-way ANOVA suggested that the participation in aural rehabilitation did affect the perception of hearing handicap by hearing-impaired adults (Table 2).

This indicated that those subjects who had received aural rehabilitation experienced a greater reduction in their perception of their handicap than those who had not received the aural rehabilitation intervention. The information provided in the cognitive style disclosure component of the intervention procedures did not seem to have a significant effect on the change scores.

Correlation of Subscales

The difference scores between the pretest and posttest scores on the Hearing Performance Inventory were used to correlate with each of the four subscale category scores from the Albany Learning Style Inventory, the instrument used to measure characteristics of learning style. The four characteristics of cognitive style measured by this instrument were magnitude, difference, relationship, and deduction.

A Pearson product-moment correlation statistic was used to measure the relationship between the variables (Table 3). The correlations obtained a positive trend in the relationship. There does not appear, however, to be enough strength within any of the correlations to imply a significant relationship between any of the identified characteristics of cognitive style and the identified components of perception of hearing handicap.

Aural Rehabilitation

The results of this study strongly indicate that newly amplified individuals can benefit from participation in a short-term aural rehabilitation program. Those individuals who received the aural rehabilitation intervention technique indicated a significantly greater reduction in their perception of their hearing handicap on the post-treatment inventory.

This conclusion supports the position taken by those specialists within the field of audiology that newly amplified hearing-impaired adults should be provided with more than mere instruction in the operation of their new hearing aids (Alpiner, 1982a; Sanders, 1982; Giolas, 1982; Davis & Hardick, 1982). The kind of program suggested by these authorities focuses on several aspects of adjustment to amplification. Emphasizing skills related to the communication process can benefit the new hearing aid user. The preliminary impression from the statistical analysis of the data in this study indicate that participation in a program that teaches communication skills can reduce self-reported hearing handicap.

Cognitive Style Disclosure

Another finding from this study was that informing adults about their particular cognitive style did not seem to have any influence on their reported success with amplification. Telling the participants of the manner in which they process information did not influence any change in their perception of their hearing handicap. It seems that while cognitive style disclosure has been shown to be an effective approach in academic situations (Fourier, 1984; Hill & Nunney, 1971; Niles & Mustachio, 1978), it did not appear to apply to this particular non-academic situation.

The literature related to cognitive style disclosure involved academic settings, principally the community college (Fourier, 1984; Hill & Nunney, 1971; Niles & Mustachio, 1978). In those settings, the students were very aware of specific expectations required of them. It is possible that the nature of cognitive style disclosure is such that it is not applicable to other kinds of instructional situations where the expectations of the learners are less clear. It is also possible that the nature of cognitive style disclosure is applicable to these other kinds of instructional situations, but that modifications in the approach need to be made.

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Table 1

Summary Table of the Means and Standard Deviations of the Difference Scores of the Four Groups on the Hearing Performance Inventory

Group	Mean	Standard Deviation
Control	30.20	72.13
Cognitive Style Disclosure Only	41.40	57.44
Aural Rehabilitation Only	104.90	59.60
Aural Rehabilitation/Cognitive Style Disclosure	100.00	43.69

Table 2

Summary Table for the Two-Way ANOVA

Row Variable = Cognitive Style
Column Variable = Aural Rehabilitation

Row Variable: ss=99.225 DF= 1 MS=99.225 F= .047
Column Variable: ss=444.22.225 DF= 1 MS=44422.225 F=20.999*
Interaction: ss=648.025 DF= 1 MS=648.025 F= .306

Error-W: ss= 76156.9 DF=36 MS=2115.469

Total: ss=121326.375 DF= 39

* *p* >.05.

Table 3

Summary Table for the Correlation Matrix

Albany Learning Style Instrument Subscales	Difference	Magnitude	Relationship	Deduction
Hearing Performance Inventory Subscales				
Understanding Speech with Visual Cues	.184	.381	.434	.296
Understanding Speech without Visual Cues	.481	.093	.186	.113
Intensity	.301	.285	.334	.116
Response to Auditory Failure	.374	.185	.200	.089
Personal	.202	.365	.090	.379
Social	.423	.152	.235	.175

APPENDIX A

Computerized Adult Aural Rehabilitation Program
J. Smaldino and R. Traynor
Little, Brown and Company
1986

Session 1 -- The Auditory System and How It Works.

Goals: To aquaint the client with the auditory mechanism, how it operates and specific disorders that can cause hearing losses operates.

To inform the client about the operation of and the difficulties encountered utilizing a hearing aid. Further to aquaint the client with assistive devices that may be beneficial.

Objectives:

1. Present and make sure each client understands anatomy of the ear.
2. Present and make sure each client understands the physiology of the ear.
3. Determine specific diagnosis for each client and explain the pathology in detail.
4. Describe the modifications often conducted on the hearing instruments to facilitate better communication.
5. Determine the situations in which the clients may have difficulty.

Session 2 -- Auditory Training

Goals: To simulate various types of progressively worse listening situations and teach the client coping strategies.

Objectives:

1. Listen and repeat word stimuli correctly when noise is progressively introduced in the background.
2. Listen and repeat phrase stimuli correctly when noise is progressively introduced in the background.
3. Listen and repeat sentence stimuli correctly when noise is progressively introduced in the background.
4. Listen to stories, in quiet and in noise, and correctly answer questions related to each.

Session 3 -- Speechreading

Goals: To utilize visual cues to augment communication.

Objectives:

1. Present and insure an understanding of basic rules for speechreading, i.e. keep hands away from mouth, etc.
2. Present and insure understanding of tips for effective communication.
3. Describe the structure of language.
4. Describe the predictability of language.
5. Demonstrate how the most obvious speech sounds look on the face.
6. Give assignment to turn down T.V. and watch a newscaster's face to determine the message presented.
7. Present specific lessons where client client needs to watch for specific lip movements.
8. Describe and practice homophenous words.
9. Describe and practice sentences that can be predicted by certain lip movements and structure of language.
10. Describe and practice sentences that can be predicted by context and situational cues.

Session 4 -- Environmental Situations

Goals: To utilize the auditory and visual skills obtained in the previous sessions to communicate in a realistic situation.

Objectives:

1. Simulate numerous situations and conduct role play with the client in quiet.
2. Simulate numerous situations and conduct role play with the client in noise.
3. Instruct the client on the use of the telephone with the hearing aid if the client is having difficulty in that situation.
4. Assist the client in developing some strategies for coping with meeting new people.
5. Assist the client in developing some strategies for coping with large group situations.
6. Assist the client in developing some strategies for coping with difficult communication situations.

Title:

Cognitive Psychology: Implications for Selection of Techniques and Measures in Instructional Research

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Cognitive Psychology: Implications for Selection of Techniques and Measures in Instructional Research

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January 17, 1988

Presented at the annual meeting of the Association for Educational Communication and Technology, New Orleans, LA (January, 1988).

COGNITIVE PSYCHOLOGY: IMPLICATIONS FOR SELECTION OF TECHNIQUES AND MEASURES IN INSTRUCTIONAL RESEARCH

Bruning (1983), among many others, reports a clear metatheoretical shift in the field of instructional design and technology from a behavioristic framework to a cognitive framework.
Gagne and White (1978) describe the cognitive theories that have contributed to this framework:

> These theories support the basic notion that the effects of instruction may best be understood by exploring the three-term relation Instruction-Memory Structure-Learning Outcome. In other words, the suggestion is made that the effects of instruction may be explained by taking into account the processing of various forms of instruction by the learner, the first results of which are the acquisition of particular kinds of new memory structures. The latter structures, in turn, are antecedents that enable the human learner to display retention and transfer in terms of new performances (p. 187).

This cognitive perspective is further described by Wittrock (1979):

> A cognitive approach implies that learning from instruction is scientifically more productively studied as an internally, cognitively mediated process than as a direct product of the environment, people, or factors external to the learner. The approach involves understanding relations or interactions between the learners' cognitive processes and aptitudes, such as attribution, motivation, encoding, memory, cognitive styles and cognitive structures, and the characteristics of instructional treatments (p. 5).

The predominant theories that are identified with cognitive psychology as it relates to instruction are gestalt theory, information processing theory, and schema theory. These theories postulate the effects of instruction on mental structures and processes and the effects of the structures and processes on learning outcomes. Many researchers in instructional technology, particularly those who aspire to contribute to instructional theory, develop their theoretical frameworks from one or more of these categories of theory.

Although cognitive psychology may have an impact upon the theory bases from which we draw our conceptual frameworks, it appears to have had very little impact upon the dependent measures and the data-collection techniques that we use in empirical studies in our field. Posttest scores seem to the primary data source in the majority of our studies, leading some critics of research in our field to liken our studies to "horse races that only look at who (which treatment) gets to the post first."

Cognitive psychology literature has provided us with data collection techniques and dependent measures that allow us to examine the influence of instructional manipulations on cognitive processes and structures. Identifying effective (and, perhaps, efficient and appealing) instructional treatments, which combinations of which instructional variables for which learners under which circumstances contributes to which learning outcomes, may be the ultimate goal of much of our research. However, failure to consider the mediating mechnaisms of cognitive processes and structures using these cognitive psychology techniques and measures is unfortunate because it deprives us of a) sensitive measures that may find subtle, but potentially potent, differences in instruction treatments; b) data that allow us to describe more completely what has happened to learners as a result of instruction; c) information that can help us to explain why we find differences in students' performances after different instructional treatments; and d) insight into additional questions that we may wish to investigate. In short, the omission limits our ability to refine, revise, or extend instructional theory.

The purposes of this paper are to a) describe data-gathering techniques and consequent dependent measures that are little used but have much potential in our field and b) validate empirically that these options are seldom used in instructional design and technology studies.

Potential Techniques and Measures

This section will describe the following four categories of data-gathering techniques and their consequent dependent measures:
a) secondary task techniques, b) eye-movement records, c) verbal reports, and d) representations of cognitives structures. Each technique and measure will be discussed in terms of processes or structures which they are hypothesized to indicate and advantages and disadvantages of each.

Secondary Task Techniques

Instructional researchers that use secondary task techniques ask the subject to complete a primary task, the learning task (such as responding to instructional materials), and at the same time give some attention to a less important, secondary, task. Generally, the variable of interest to the researcher is the latency, the speed of performance of the secondary task. Most often, this type of technique and measure is used within a limited capacity model of working memory. The model postulates that the longer it takes the subject to respond to the secondary task, the greater the amount of working memory is dedicated to the primary, learning, task. Special equipment is generally required to use this type of measure, as cognitive operations may occur very fast, 1 - 250 milliseconds (Gagne, 1985).

Britton, Piha, Davis, and Wehausen's study (1978) is example of the utility of this technique. Previous research had established that inserted questions in textual materials improved comprehension. Britton et al. questioned **why** this occurs. In their study, one-half of the subjects received inserted questions, the other half received text only. During the reading task, the subjects were given a secondary task of responding to audible clicks by releasing a button. As the researchers predicted, the students in the inserted questions group had longer response latencies than the text-only group and, as with past research, their comprehension was greater. Britton et al. interpreted this result to indicate that comprehension was greater by those subjects that received inserted questions because the questions caused the learners to invest greater cognitive capacity (e.g., to try harder) in the learning task.

Levin, Dretzke, McCormick, Scruggs, McGiven, and Mastropieri (1983) collected latency data for a different purpose. In their studies investigating the effects of using a mnemonic picture strategy on learning the order of the U.S. presidents, one-half of the learners were taught a mnemonic strategy for remembering verbal information, the remaining half of the learners, the control group, were allowed to use any strategy they wished. During the recall test, the researchers timed the delay between the presentation of the question (e.g., "which number was Lincoln?") and the subject's response. They found that the response latency for subjects in the experimental group was significantly longer than for those in the control group. The investigators concluded that this difference was due to the "complex retrieval demands" of the mnemonic strategy, an evidence of the stubjects' using the strategy.

A major disadvantage of such approach is the difficulty in acquiring the equipment to record and analyze reponse times. In addition, there have been some criticisms of the inferences that can be made based upon such data. For example, learners seem to be able to learn to accommodate the secondary task with practice until response becomes almost automatic, regardless of the depth of processing required by the primary task (see Fisk, Derrick, & Schneider, 1982; Jacobs, Dempsey, & Salisbury, 1987) (See Britton, Meyer, Hodge, and Glynn (1980), Kahneman (1973), and Kerr (1973) for additional information on this technique.)

Eye-movement Records

Eye-movement records provide researchers information about where and for how long a subject fixes his or her gaze upon a given display. Such data gives researchers data regarding where a subjects' attention is focused a given point in time and sequentially how this attention is changed over time. Eye fixations (periods of time when eyes cease motion) may also give investigators some indication of the points at which learners pause to reflect, providing information of how learners "chunk" information. Eye movements, such as "look forwards" and "look backs," may provide information as to points at which confusions arise. (For more information on interpreting eye movement data, see Farnham-Diggery & Gregg, 1975; Just & Carpenter, 1980; Snow, 1968.) Often, the processing that may be inferred by such movements is so automatic that it is unavailable to other forms of observation and is not recollectable, and, therefore, unavailable to subjects for retrospective recall (see later section on verbal reports). Eye movements may be the only source of information about some refined aspects of processing.

Eye movements may be classified a micro or macro movements (Schumacher and Waller, 1985). Micro-eye-movements are fixations, regressions, and movements that focus on individual units of a text or pictorial display. Such movements are recorded by recording the reflection of a small amount of light, usually infrared, off the cornea of the subject's eyes. The reflection of the light is recorded by a photoelectric device that is usually interfaced with or an integral part of a computer. Equipment is generally fairly expensive and sophisticated, requiring some knowledge of computer programming to set various parameters of the equipment. Also, the equipment often requires that the subject's head movements be restricted in some way, limiting the ecological validity of the study, and, therefore, the generalizability of the conclusions.

Some studies investigating the effects of computer or print displays may not require a record of the fine-grained movements provided by the micro-movement equipment. In such cases, investigators may wish to measure macro-eye-movements. Macro-eye-movements are grosser eye movements across larger segments of the display, such as across paragraphs and pages of text. Schumacher and Waller describe three types of procedures that are suitable for recording macro-movements. The first (Whalley & Fleming, 1975) records the movement of a light-pen which the subject moves across pages of text. This technique allows the investigator to note the time that the subject spends on each segment of text, look backs, and look forwards. The second (Pugh, 1979) videotapes two images, eye movements and text of a page, through the use of a semi-silvered plate of glass. This procedure allows the investigator, by viewing the videotape, to note lookbacks, lookforwards, note taking, and hesitations. The third procedure (Hout Wolters, 1982) involves the subject moving a special pen across a text page as (s)he reads. It does not directly record the eye movements of the user. An advantage of this equipment is that it also can measure response latency and galvanic skin responses. (For more information on eye movement recording equipment see Egan & Grimes-Farrow, 1976; Gulf and Western Research Development Group, 1978; Koff, Elman, & Wong, 1971; Young & Sheena, 1975)

Fleming (1984) used eye movement equipment to record the duration of attention to word and picture elements of a display and to record the patterns of transitions between display areas. He was investigating the effects of two variables: level of complexity of information (simple vs complex) and page layout (picture first vs text first). Learner variables included in study were gender, cognitive style (field independence/field dependence), and prior knowledge. Dependent measures were durations, transitions, and sequences of eye movements. Fleming found that

- females' durations were longer overall,
- all subjects' durations were longer for complex than for simple material,
- there was an interaction between cognitive style and complexity on the number of transitions, with field independents making fewer transitions on simple materials and more transitions for complex materials than did field dependents (e.g., they adjust processing according to complexity of materials),
- males (as compared to females) tended to make more reverse transitions when given the words first layout (they tended to look at the pictures first).

In addition to the expense and complexity of such equipment, there are three other potential disadvantages of such techniques. First, as noted earlier, some of the equipment requires that both stimulus materials' and subjects' be fixed in unnatural or fixed positions. Such a requirement may limit the generalizability of the conclusions of studies using such equipment. This disadvantage seems to be more significant for the micro-eye-movement techniques. Second, as with secondary task techniques, researchers must be cautious in the inferences regarding processing that they make in response to such data (Just & Carpenter, 1980; McConkie, Hogaboam, Wolverton, Zola, & Lucas, 1979). Such limitations may be somewhat obviated by collection of complementary data, such as verbal reports. For example, videotapes resulting from use of one of the procedures described above might be used to stimulate retrospective verbal reports. Third, these data collection techniques result in many data points that must be reduced for analysis. However, the more sophisticated micro-movement equipment often include reduction and analysis programs that produce graphic representation and other analyses of movement data.

Verbal Reports

Verbal reports are subjects' verbal statements that are made before, during, or after performing a learning task (Gagne, 1985). Verbal reports can be concurrent, occurring as the subject completes the task, or retrospective, occurring after the subject has completed the learning task. Subjects in studies using these techniques are generally asked to verbally (generally, orally) describe what they plan to do to complete the task, what they are thinking about as they complete the task, or what they did as they completed the task. The intermediate stage, describing what is thought about while completing the task, is often called a "read-think aloud" technique (Flower and Hayes, 1981).

These verbal responses are typically transcribed into written form, **protocols**, and examined for patterns of responses, **protocol analysis** (Ericsson & Simon, 1984). These protocols can be examined for such processing features as generation of mental elaborations (additional examples, inferences, comparison, analalogies, mnemonics), paraphrases, misconceptions and their rectification, summarization/review/rehearsal, organization, self-monitoring, rereading, imaging, and questioning. Reduction of the voluminous data that results from such a techique usually involves some qualitative research techniques. Using this data, researchers can look for differences in processing patterns which may be due to manipulation of instructional variables.

Levin, Dretzke, McCormick, Scruggs, McGiven, and Mastropieri (1983) used verbal report data in their study investigating the effects of using a mnemonic picture strategy on learning the order of the U.S. presidents. After they completed the learning task, subjects were asked about the strategies that they employed during the recall task. The investigators used this technique to determine the degree to which those instructed on the mnemonic strategy actually used it and whether those who were not instructed on the strategy used a similar strategy (factors which might have confounded their results).

Wedman and Smith (1986) are using a read-think aloud procedure to investigate the processing differences between subjects who are learning the relationships of camera variables from either a hierarchically organized strategy or an elaborated strategy. Thus far, the data has led them to tentatively conclude that subjects studying the elaborated version are more facile in solving problems that involve the manipulation of two or more variables.

As with the other techniques, verbal reports have some limitations. First, the amount of data that is produced using such techniques is considerable, therefore, reduction of the data is extremely time-consuming and tedious. This limitation results in either a) using probed recalls to focus on only particular aspects of the subjects' processing or b) limiting the number of subjects used in a study of this nature.

Second, verbal reports are subject to some of the same problems of other self-report data: Subjects may respond in a manner that the feel the researcher wishes to respond. In addition, subjects can discuss only that which is conscious on their part. Much of the processing that they engage in may be as hidden to the subject as it is to the researcher. This may lead subjects into making inferences about their own processing to complete incomplete recollections.

Third, and probably most significant, the procedures employed make more demands on the limited capacity of working memory than the learning task itself, leading researchers to question the validity of both the processing information and the task performance data. This is especially a limitation with concurrent verbal reports. The subjects' attempts to report their own processing may subvert their performances on the learning task which may in turn invalidate their processing techniques. Ericsson and Simon (1980) describe the limitations of verbal reports and the conditions under which such techniques are most valid. Some of their suggestions are that a) in concurrent reports, subjects should be asked what they are doing rather than how or why they are doing something, b) that retrospective reports follow immediately after the task and are cued by evidences of the subjects actions (such as video tapes of the subject completing the learning task), if possible, and c) that probing questions are very specific "Did you break the task into subgoals? Which subgoals did you break the task into" rather than general "Did you use a problem-solving technique?"

Representations of Cognitive Structure

The previous three techniques are used to make inferences about the cognitive processes that subjects engage in as they complete a particular learning task. The final category of techniques attempt to acquire a physical representation of the cognitive structures of subjects. Originally, these techniques were developed in order to compare the cognitive structures of learners with the content structure of material to which they have been exposed (Preece, 1976; Shavelson, 1972). These techniques may be used, however, to compare the mental representations of content that are developed as a result of studying two or more versions of instruction. In other words, they may be used to examine the effects of instructional variables on cognitive structure.

The data that is obtained from these techniques are indices of the semantic proximity or semantic distance between pairs of words. Several procedures that are used to gather this information are

- word association tests
- construction of linear graphs (trees)
- similarity ratings
- free recall (with an examination of extent to which particular words are clustered)
- sorting tasks (Preece, 1976)

The first three techniques are the most commonly used and will described in the following paragraphs. The reader may wish to refer to Preece for descriptions of the latter two techniques.

In word association tests subjects are presented with a stimulus words and are asked to respond with the first word, or all the words that they can think of. Scores that are generally obtained are a) the total number of responses to a stimulus word, b) the average number of responses to the stimulus words, c) the number of responses of a particular kind, and d) the overlap of response lists for pairs of concepts (Shavelson, 1974). The data can be reduced into a matrix of similarity coefficients which may in turn be analyzed statistically with factor analysis, multidimensional scaling, or hierarchical cluster analysis.

When using the second technique, construction of linear graphs, the researcher asks the subjects to draw a physical representation of a set of concepts. In this technique subjects may be given very directive instruction or they may be taught a graphing technique and later asked to use it. An example of directive instructions might be

> Below is an alphabetical list of 10 terms. Read the list carefully several times. From the list of terms, pick the two terms which you think are "most similiar" to each other. Write the pair you have chosen in the middle of the page and connect them with a line. Label this line 1. Go carefully over the remaining terms in the list and pick the term which you think is most similar to to either of the two terms you have already selected. Label the connecting line 2 . . . (Shavelson, 1974).

Subjects may also be taught a graphing technique such as networking (Danceareau, Collins, McDonald, Holley, Garland, Diekhoff, & Evans, 1979) or making pattern notes (Buzan, 1974; Jonassen, 1983) prior to being exposed to the learning task. After experiencing the instructional treatments, the subjects can be asked to make a graph of the content using the newly learned procedure.

These graphs are converted to symmetric proximity matrices. Then such statistical techniques as cluster analysis and multidimensional scaling may be used to uncover the structure underlying the data. Jonassen reports using a the program ALSCAL (Young & Lewyckyj, 1979) the scale the data.

Jonassen (1983) describes comparing the representations that were obtained using pattern notes and word association techniques. He found that "the clusters produced by scaling the relatedness coefficients and the distances between concepts are very similar." (p. 14)

Researchers using the third technique, similarity ratings, provide subjects with paired concepts and ask the subjects to rate the concepts as to their similarity. For example, the subjects might be asked to rate two concepts on a scale of one to ten with one being "closest" or "most similar." These ratings can be converted to proximity matrices and then subjected to factor analysis or multidimensional scaling techniques. Some individuals in our field may have recently participated in Jonassen's study which collected similarilty ratings of instructional technology and related terms.

Summary

Four techniques from cognitive psychology literature were described: a) secondary task techniques -- latency data, b) eye-movement records -- eye fixations, c) introspective/retrospective verbal reports -- categories of processing activities, and d) representations of cognitives structures -- indices of semantic proximity. The characteristics of each technique, its advantages and limitations, were discussed. An example from instructional research of each technique was presented. It was suggested that several techniques can used together to get a profile of learners' processing and resulting structures. In addition, researchers might consider using these techniques in conjunction with posttest or other outcome information in order to explain the results the are obtained.

Analysis of Current Practice

The second part of this paper reports on a review of recently reported research in our field to examine the degree to which the four techniques described earlier have been used in studies reported in AECT publications.

Data Source

Articles and papers published in Educational Communication and Technology Journal 1983-1987 and the Proceedings of Selected Research Paper Presentations at the (1983-1987) Annual Convention(s) of the Asssociation for Educational Communications and Technology were reviewed. Although a larger sample of articles might have given a more accurate profile of use of the cognitive psychology techniques, I considered this sample to be quite adequate for an initial examination of the literature. This sample comprised 17 issues and 78 articles of ECTJ and five issues and 208 articles of the RTD Proceedings. A total of 286 articles were examined. Of these, 3 papers were eliminated as duplicates, leaving a total of 283 papers for review.

Procedure and Results

Each paper was reviewed and categorized with a series of nested categories. First, it was determined whether the article was data-based. **One hundred seventy-four** of the articles were so categorized. Articles that did not fall in this category were conceptual and advice-to-practice in nature. These articles were eliminated from further analysis.

Second, the remaining articles were categorized as to whether they investigated the effects of an instructional variable or instructional variables on learning outcomes. **One hundred and seventeen** of the articles met this criterion. For the purposes of this study, articles that examined the effects of an instructional program, such as Logo, or an instructional medium, such as media comparison studies, were eliminated from this category. Studies that did not fall into the instructional variable effects category were eliminated from further analysis.

Next, the 117 articles were examined and categorized as to whether they explicitly espoused a cognitive psychology theoretical framework. To be so categorized the author(s) must have explicitly referenced cognitive processes or structures in substantiating predictions, in explaining treatments, or in discussing results. Sixty-six articles were included in this category. The articles not included in the category used other theoretical framevords, such as social learning theory; used previous research as a framework; predicted or explained results in terms of intuition or pragmatic conclusions, or did not include a framework. Articles not included in this category were not analyzed further.

Finally, the 66 articles were analyzed as to data-gathering techniques and dependent measures to ascertain which used the four techniques described above. Of the 66 articles, only six were so categorized: one used response latency data, three used eye movement data, three used verbal reports, and none used mental representations. One study used two of the above techniques, so was tallied twice. It should be noted that several of the articles that did not reach this level of categorization included these techniques, (e.g., Jonassen's article comparing the mental representations achieved through word association and pattern notes techniques). An examination of the articles did not reveal any similar techniques not included in the previous discussion but appropriate techniques for examining cognitive processing or structures. The vast majority of studies classified in this final category collected only posttest data.

Discussion and Conclusion

An examination of 283 articles published in the field of instructional technology revealed that only six of the articles that examined the effects of instructional variables on learning outcomes and claimed a cognitive psychology framework used the techniques described in this paper. While there may be some error in categorizations, this finding represents a fairly accurate analysis of the current use of the techniques that have been suggested in cognitive psychology literature as indications of cognitive processing and cognitive structures. One might conjecture as to why this is the case. Researchers in the field may

- be most concerned with the ultimate question -- which instructional variables have the greatest effect on performance?
- not have resources and training to employ the these techniques,
- not consider the information that these data provide of value, or
- be unaware of these techniques and their potential.

If this latter conjecture has any validity (and it may as information describing these techniques is not synthesized in any source that I located, with the exception of a brief review of the first three techniques by E. Gagne, 1985) then perhaps this paper may provide a beginning point for researchers to examine the techniques' potential.

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Title:

The Effects of Organization of Instruction on Cognitive Processing

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The Effects of Organization of Instruction on Cognitive Processing

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January 18, 1988

Presented at the annual meeting of the Association for Educational Communications and Technology, New Orleans, LA (January, 1988).

The Effects of Organization of Instruction on Cognitive Processing

Traditional models of instructional design (Gagne & Briggs, 1979; Merrill, 1984) detail specifically how to design instructional strategies at the micro level. This is, they specify the sequence of events that should be included in instruction toward an individual objective. For instance, they suggest that when teaching toward a concept objective, the instruction should include a verbal statement of the definition of the concept, examples and nonexamples of the concept, and an opportunity for the learner to classify examples and nonexamples according to the concept's definition.

Yet, design models rarely suggest strategies for organizing instruction at the lesson, unit, or course level. To date, perhaps the most frequently used strategy for organizing instruction at these macro levels is the learning prerequisite sequence suggested by Gagne (1972). Several studies have examined the effectiveness of instruction designed using learning hierarchy prescriptions (e.g., Beeson, 1977; Eustace, 1969; Gagne, 1962; Headley, 1971; McCain, 1971; Okey, & Gagne, 1970). These studies typically compared instructional effectiveness before and after instruction using learning hierarchies and found hierarchically-arranged instruction to be generally superior to instruction designed using other means. However, such an approach may yield instruction that appears piecemeal, producing learners who have acquired individual skills and bits of knowledge, but who have failed to acquire the "big picture," a fully integrated schema of the content.

Instruction organized solely by prerequisites are generally unresponsive to the unique content structures of particular disciplines Therefore, such models may fail to take advantage of schemata that learners have already developed from encounters with traditional content structures in extant instructional materials.

Reigeluth is responsive to these criticisms of traditional design models by espousing the design of instruction based upon his Elaboration Theory of Instruction. The Elaboration Theory suggests that designers should begin the design of instruction by selecting an overriding organizational structure: conceptual, theoretical (based upon principles), or procedural. It further supports a method of sequencing instruction from the most simple and inclusive ideas in the content to the most complex and specific ideas. Reigeluth has borrowed the basis of this simple-to-complex pattern from Bruner's (1960) ideas of a spiral curriculum, from Ausubel's (1968) assimilation theory, and from Norman's (1973) concept of web learning.

The Elaboration Theory predicts that instruction designed on its principles will result in a) more fully integrated schemata, resulting in better retention and transfer at the application level; b) higher levels of learner motivation; and c) more efficient instruction based upon greater learner control of selection and sequencing of content than materials developed using more traditional macro strategies (Reigeluth & Stein, 1983).

However, empirical studies have failed to fully support these predictions (Beukhof,1986; Reigeluth & Stein). One possible reason for this failure is that researchers have not examined a full range of data sources when examining the differences between performances of learners encountering materials designed according to the Elaboration Theory versus more traditional approaches. Smith and Wedman (1986) proposed a number of additional data sources that might be sufficiently sensitive to examine some of Reigeluth's predictions.

The purpose of the current study was to compare the effects of an elaborated unit of instruction versus a hierarchical unit on students "on-line" processing activities, efficiency of encoding new information within the lesson, and facility in solving practice problems.

Method

Participants. Six university graduate students in the College of Education at a univeristy in the southwest who were rated as novice on the to-be-learned content (scoring less than 3 on a 15 item pretest) participated in this study. Students were randomly assigned to either a hierarchical or an elaborated version of the instruction (three students to each treatment).

Materials. Two versions, a hierarchical verson and a modified elaborated version, of a unit on Principles of Photography were developed. Both versions were developed to teach toward the objective "Learners will be given a setting (shutter speed and f-stop) that will yield a correct exposure and a clear image and a changing condition (lighting, motion, field of view, or film speed). They will be able to determine a correct setting, film speed, or other accommodations that will yield a correctly exposed, clear shot under the changed condition."

The elaborated version consisted of 105 pages, the hierarchical version, 80 pages. The content that was indicated in an instructional analysis to be prerequisite to learning the terminal objective was present in both treatments. Both sets of materials contained sequences of information presentation, practice items, and feedback.

The elaborated version contained an epitome, which introduced the variables (e.g., amount and duration of exposure) that affect picture quality and the relationship of these variables within an analogy. The epitome required the students to make non-numerical predictions about the relationships of these variables within specific contexts. The second part of the elaborated version introduced the numeric values associated with the previously-introduced variables and the numeric relationships between these variables. It also included synthesizers that tied each section of the second part of the unit to the epitome. The elaborated unit did not include the following aspects of elaborated instruction: summarizers, cognitive-strategy activators, and explicit invitations to exercise learner-control.

The hierarchical version introduced each principle of creating quality photographs (e.g., correct exposure, clarity, etc.) and its related concepts in a sequence indicated by an instructional analysis. A 15-item pretest that contained near transfer items was administered to all participants. In addition, 70 embedded practice items were constructed to evaluate within-instruction learning (seven in the targeted section of instruction).

Procedure. Participants were introduced to the study and agreed to participate. Although they had been previously screened to ascertain that they were essentially novices in the content, they all completed a pretest. They were then trained and allowed to practice a read-think-aloud procedure in which they read the content aloud and attempted to make oral any thought processes that occured as they interacted with the materials.

After the experimenter was satisfied that the participant could use the procedure, the participant was presented with the first part of the materials, the tape recorder was started, and the student began to read and interact with the materials aloud. If the participant began to be silent, (s)he was prompted "what are you thinking /reading now?" After the student completed Part 1 (approximately 30-60 minutes), (s)he was given a 15-minute break. After the break, the student was reminded to "read and think aloud" and the tape recorder was started again. A break followed Part 2 (approximately 30-45 minutes), then Part 3 was completed (30-45 minutes). Entire instructional time ranged from two to three hours. As a comparison of posttest performance was not of interest in this particular study, no posttest was given.

Scoring. The read-think-aloud protocols were transcribed. Due to the volume of the data, only one section of these protocols was analyzed in this study. The researchers predicted that the difference in the effects of the two treatments would be greatest at the point in which the learners were required to manipulate a number of variables mentally at one time. Therefore, the segment of instruction that included the information presentation, practice, and related feedback on determining equivalent exposures was selected for this initial analysis.

First the protocols were examined for patterns of responses in the following areas: generation of examples, inferences, comparisons, analogies, mnemonics, paraphrases, misconceptions and their rectifications, summarization/review/rehearsal, self-monitoring, rereading, imaging, and questioning. Frequencies and durations of the above activities and their location within the materials were noted. During the analysis of these protocols the following categories of elaboration emerged: confusion, question, repeat/reread, paraphrase, elaborated paraphrase, retrieve concept definition, retrieve rule, summary, prediction, rule expansion/ application, tie to prior knowledge, example.

Time for encoding the new information presented in the targeted section and total learning time for the package were recorded. In addition, the number of correct responses to the practice questions in the targeted section was calculated.

Results

Elaborations. Table 1 summarizes the frequencies of processing types for the hierarchical and elaboration groups.

Insert Table 1 about here.

As can be noted from the above Table participants responding to the hierarchical version performed many more elaborations than participants responding to the elaborated version.

Practice item performance. Of the 7 embedded items the average performance of the hierarchical group was 5.3, of the elaboration group was 4.3.

Time (facility) encoding. The average reading time of the targeted section for the hierarchical group was 8.3 minutes, of the elaboration group was 6.0.

Discussion and Conclusions

Of greatest interest in this set of data are the elaborations and the encoding times. The differences between number and type of elaborations bears further investigation. It may be that as participants in the hierarchical group had not had a cognitive structure built through an epitome (as the elaboration group may have) they needed to make a greater number of elaborations to build this schema.

The differences in encoding time for this section were as predicted. It was conjectured that learners that had been exposed to the epitome would be more facile in encoding new information because they would already have a cognitive structure of the basic relationships among variables into which the more detailed information could "hook." Therefore, it was expected that the elaboration group would take less time in encoding this information than the hierarchical group who would have to build the cognitive structure of relationships as they encoded the new information. The fairly substantial difference in encoding times seems to support this conjecture.

The time of encoding and number of elaborations seem to support each other and the conjectures as to the function of the elaboration in the instruction. However, conclusions from this study must be very tentative due to the small number of participants. Future investigations may examine this relationship more closely.

In addition, future studies in this area may wish to examine participants' mental representations of the content by training them in a networking/pattern notes strategy and asking them to summarize the content that they have read in these forms. A comparison of the notes created by participants in elaborated and hierarchical groups might lead to some conclusions as to whether the prediction of more integrated schemata resulting from elaborated instruction can be substantiated. Other researchers may wish to examine the interactions between level of prior knowledge or processing style (such as wholist/serialist) and effectiveness of elaborated/hierarchical instruction. Certainly, future investigations should expand elaborated versions to include many levels of elaboration and all definitive characteristics of elaborated instruction.

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Table 1

Frequency of Elaborations in Specific Categories for Participants in Hierarchical Versus Elaboration Groups

Type of Elaboration	Hierarchical	Elaboration
Confusion	3	0
Question	5	1
Repeat/reread	1	2
Paraphrases	7	2
Elaborated paraphrases	2	1
Retrieve concept definition	1	0
Retrieve rule	1	0
Summary	1	2
Prediction	5	1
Rule expansion/application	3	0
Tie to prior knowledge	3	0
Example	0	1

Title:

Toward a Taxonomy of Feedback: Content and Scheduling

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Toward a Taxonomy of Feedback: Content and Scheduling

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TOWARD A TAXONOMY OF FEEDBACK: CONTENT AND SCHEDULING

The two dimensions of feedback that will be discussed in this paper are content and scheduling. Each dimension and the elements within each dimension will be defined, some general conclusions from the research investigating the elements will be discussed, and further questions with regard to further research will be identified. Greatest attention will given to the first dimension, content, as a subsequent paper will discuss it.

Content

The content of feedback refers to the composition of the information provided to a learner after his/her response to a question within an instructional sequence. The effectiveness of different types of feedback content has been probably the most researched issue in the area of feedback. Two major categories of feedback which have been researched are **motivational**, reinforcing, feedback and **informative**, corrective, feedback.

Motivational

Motivational, reinforcing, feedback is information, which may include praise or other rewards, that follows a correct response. The feedback message may include only a right/correct message, similar to Knowledge of Results feedback which follows a correct answer. In general, studies of this element have not examined "punishing" feedback following incorrect responses. The purpose of motivational feedback is to reinforce correct responses, and, thereby, increase the repetition of correct responses. Motivational feedback was the first type content feedback that was researched, with much of this research being conducted with programmed instruction and within the theoretical framework of behaviorism.

While there are a few studies (e.g., Campeau, 1968) that support the efficacy of reinforcing feedback over no feedback, the majority of studies in this category (e.g., Becker, 1964; Feldhusen & Birt, 1962; Hough & Revsin, 1963; Jacobs & Kulkarni, 1966; Lasoff, 1981; Moore & Smith, 1964) have found no significant effects of confirmatory feedback or confirmatory feedback with praise over the no feedback condition.

Extensive discussion in the literature has centered around a) whether confirmatory feedback is indeed reinforcing and b) whether confirmatory feedback is a potent variable in instruction. Sassenrath, 1975), Sassenrath & Younge, (1969), and Bardwell (1981) concluded that confirmatory feedback did not serve as a reinforcer of correct performance. Smith and Smith (1966) suggested that confirmatory feedback will not serve as reinforcement unless learners always make correct responses.

In general, most current research on feedback, which is based upon cybernetic psychology and information processing theory, suggests that feedback serves an informational, error detecting and correction function, rather than a reinforcement function (Ammons, 1956; Smith & Smith, 1966) and that feedback may be more effective after incorrect responses, rather than correct ones (Carter, 1984; Cohen, 1985; Kulhavey, 1977, Phye, 1979).

Informational Feedback

Informational, often corrective feedback, is information that is provided to learners following their response to question within an instructional sequence. This type of feedback provides learners with information

- about the adequacy of their responses, and/or
- that helps them to detect and correct their errors and misconceptions, and/or
- that helps them to understand why a particular correct answer is correct.

The primary purpose of informational feedback is error detection and correction in order to reduce the potential of an error occurring during future performance. While the effects of informational feedback has been studied following both correct and incorrect responses, the majority of studies have focused on the efficacy of informational feedback following incorrect responses.

Informational feedback has been subdivided into a variety of categories (Carter, 1984; Roper, 1977; Sales, 1985). To simplify these categories, this paper will refer to four major types of informational feedback: a) no feedback, b) "correct/incorrect" message, c) presentation of correct answer, d) elaborative feedback. The variations within each category and the conclusions of related research will be discussed in subsequent sections.

No feedback. This category of feedback is obvious. Instructional treatments that contain no feedback do not provide information either implicitly or explicitly about the accuracy of response or explanation of correct or incorrect responses. Occasionally, programs do not present verbal statements of feedback, but implicitly give learners information about the accuracy of their responses (e.g., a program that establishes the "set" that when answers are correct the program will continue with the next frame of information.) Such programs do not truly reflect the "no feedback" category.

Learners who do **not** receive feedback during instruction must complete all of the following processing on their own:

- Was I right/wrong?
- What is the correct answer?
- If I'm wrong, why?
- Why is the correct answer correct?
- How can I find out why (I'm wrong or right)?
- How am I doing in this lesson?

Barringer and Gholson (1979) concluded from a review of the feedback literature that "no feedback" conditions consistently receive the lowest scores on criterion measures in contrast to other forms of feedback.

"Correct/incorrect" message. Feedback of this type tells learners, either explicitly or implicitly, whether their responses are correct or incorrect. (This is often referred to the literature as Knowledge of Results (KOR) feedback.) The most common form of this message is "Right" or "Wrong".

Studies indicate that KOR feedback is superior to no feedback (Roper,1977; Schimmel, 1983). This may be because the first processing requirement

- Was I right/wrong? ✓
- What is the correct answer?
- If I'm wrong, why?
- Why is the correct answer correct?
- How can I find out why (I'm wrong or right)?
- How am I doing in this lesson?

is provided, decreasing the learners' cognitive processing load. The no feedback condition places a heavy load a) learning new content and b) a high level of strategy use, such as self-monitoring and inferencing on the limited capacity of working memory. The "correct/incorrect" feedback reduces the demand by reducing the amount of inferencing that must occur.

Presentation of correct answer. This form of feedback informs learners of the correct answer to the question they have just answered. (This type of feedback is often called KCR in the literature. However, some studies use KCR to represent confirmatory feedback after correct answers. The label KCR will not be used in this paper.) The majority of research indicates that this type of feedback is superior to correct/incorrect feedback or no feedback, especially when it follows incorrect responses (e.g., Gilman, 1969). Correct answer feedback supplies the following processing required of a learner:

- Was I right/wrong? (✓)
- What is the correct answer? ✓
- If I'm wrong, why?
- Why is the correct answer correct?
- How can I find out why (I'm wrong or right)?
- How am I doing in this lesson?

The inference that learners must make given the correct answer as to whether their answer is right or wrong seems a fairly straightforward and undemanding comparison of response to correct answer. This inference ("Am I right/wrong?") probably requires little cognitive effort, especially if the learners' responses are available on the same frame as the feedback.

Elaborative feedback. Elaborative feedback includes those more complex forms of feedback that explain, direct, or monitor. They may or may not be used in conjunction with KOR or correct answer feedback.

Explanatory feedback. This category includes feedback that explains why a correct answer is correct and/or why an incorrect question is incorrect.

- Was I right/wrong? (✓)
- What is the correct answer? (✓)
- If I'm wrong, why? ✓
- Why is the correct answer correct? ✓
- How can I find out why (I'm wrong or right)?
- How am I doing in this lesson?

Explanation of why an incorrect answer is incorrect or why a correct answer is correct may be presented separately or together in the same feedback. Explanatory feedback may (or may not) include a statement of whether learners are correct or incorrect. It may (or may not) include a presentation of the correct answer. If only an explanation of why an incorrect answer is incorrect is given, the correct answer and why it is correct will have to be inferred.

Occasionally, as in a simulation, this type of feedback may explain an incorrect or correct answer by revealing the consequences of that answer (e.g., "no, if you re-adjust the master lever at this time, the spockets will catch on the secondary gear").

Directive feedback. Directive feedback may cue or prompt learners as to strategies to determine the correct answer, giving suggestions as to solve a problem, as in Landa's (1974) algorithmic feedback, or where to direct attention, as in Merrill and Tennyson's (1977) attribute isolation feedback. Directive feedback might be as subtle as a branch to review frames in a lesson, directing learners to the information that they have failed to understand. Directive feedback generally follows incorrect responses, although theoretically some directive feedback types, such as attribute isolation feedback, could follow correct answers.

- Was I right/wrong?
- What is the correct answer?
- If I'm wrong, why?
- Why is the correct answer correct?
- How can I find out why (I'm wrong or right)? ✓
- How am I doing in this lesson?

Directive feedback is often used in conjunction with interactions that allow for a second try.

Monitoring feedback. Monitoring feedback, sometimes called advisement (Sales, 1985), provides learners with information as to how well they are performing in the lesson. Such feedback might inform learners how close they are to a criterion, such as mastery. This type of feedback somewhat supplants the metacognitive strategy of self-monitoring.

- Was I right/wrong?
- What is the correct answer?
- If I'm wrong, why?
- Why is the correct answer correct?
- How can I find out why (I'm wrong or right)?
- How am I doing in this lesson? ✓

Despite investigators attempts to establish that elaborative feedback is more effective than less complex feedback, thus far, data has generally failed to support their claims (Schimmel, 1983,1987). This finding may be due to two different factors: complex interactions and counterbalancing cognitive processes.

Complex Interactions

Researchers in the area of feedback are beginning to realize that the quest to find the single best feedback treatment overall may be less simple than it once appeared. There are many factors that may interact with the instructional variable, feedback, which may make its effects differential.

Insert Figure 1 about here.

Particularly critical to the effectiveness of feedback may the variables of type of learning task, learner characteristics, instructional event being delivered, and the type of performance measure.

Instructional events became apparent as a confounding variable as the author reviewed the current literature. Feedback studies investigate feedback after pretests, during practice, after/during tests. As the function of these events are quite different, it seems that feedback must function differently in these events as well. Findings in the area of feedback may seem so equivocal because of reviewers attempts to generalize results across completely different instructional events. Once these potentially interacting factors are crossed with the elements of the various of dimensions of feedback presented in this seminar, it is clear that this area of study may be very complex indeed.

Counterbalancing Cognitive Processes

As can be seen in Figure 2 there are two counterbalancing factors of cognitive processing that may somewhat explain the unexpected findings relative to the potency of elaborative feedback

Insert Figure 2 about here.

As can be seen on the left side of the scales, the more complex the feedback, the more processing information regarding the questions

- Was I right/wrong?
- What is the correct answer?
- If I'm wrong, why?
- Why is the correct answer correct?
- How can I find out why (I'm wrong or right)?
- How am I doing in this lesson?

it provides, the less of the limited capacity of working memory must be dedicated to "figuring out" the answers to these questions, and the greater the amount of working memory can be allocated to the new content of the lesson itself. Therefore, one would predict, as many researchers have, that the more complex the feedback, the greater the learning. However, theoretically, the mechanism is not as simple as this.

As can be seen on the right side of the figure, the less information that is presented to learners in feedback the more processing that are required to do in order to answer the processing questions

- Was I right/wrong?
- What is the correct answer?
- If I'm wrong, why?
- Why is the correct answer correct?
- How can I find out why (I'm wrong or right)?
- How am I doing in this lesson?

This, to a point, leads to a greater depth of processing (Craik & Lockhart, 1972) which in turn leads to greater learning and retention (Craik & Tulving, 1975). Wittrock (1974) refers to this phenomenon as the **generative effects** of learning. When learners are asked to supply more of the processing, rather than having it supplanted by instruction, they, to a point, learn and recall more. Therefore, with this theoretical perspective, the order of the predicted effects of the different types of feedback is reversed, with "no feedback" predicted as being the most effective form of feedback as it requires the greatest processing. The general conclusions of feedback literature may serve as an indication of where, overall, the balance of these counterbalancing forces "tip".

no feedback < KOR < correct answer > elaborative

The pattern of greater complexity of feedback leading to greater learning gains does not continue through elaborative feedback. The pattern breaks between correct answer feedback and elaborative feedback. It may be that at this point (for most learners, for most tasks, for most events, for most performance measures) the benefit of the depth of the processing required of making inferences from the given feedback information (correct answer) may outweigh the cognitive capacity payoff of providing the more complex feedback. The puzzling out of why an incorrect answer is incorrect and why a correct answer is correct may be a function that learners need to supply themselves.

This conjecture has not been fully tested with extant data, much less investigated with new studies. It may have some benefit to explaining some of the equivocal findings in the literature.

Scheduling

This dimension refers to the decisions as to **how often** feedback will be provided to learners within an instructional sequence. Scheduling is distinct from another dimension, timing, which generally refers to **when** feedback will be presented in relation the learners' response (e.g., immediate, delayed). In most studies of feedback, the feedback immediately follows the response. However , this pattern can be altered. There are three major categories of scheduling. Feedback can be provided

- for each item
- for a certain percentage of items
- after a certain number of correct/incorrect items.

For each item. Most of the studies that were discussed earlier with regard to content utilized this form of feedback, providing whichever form(s) of feedback being investigated after each item. This is a common pattern for presentation of informational feedback.

For a certain percentage of items. Feedback on a percentage schedule provides feedback for only a certain percentage of the items (e.g., 20%, 40%, etc). Feedback may be **randomly** apportioned according to this percentage, or on a **fixed** schedule (e.g., after every third item).

After a certain number of correct/incorrect items. Feedback of this type generally presents cumulative information after a learner has answered a set number of items correctly or incorrectly (e.g., "Good you gotten 6 items correct.")

Most of the research with scheduling seems to utilize motivational, reinforcing, confirmatory feedback. This is consistent with the behaviorist theoretical groundings which underlie both aspects. Schedules of reinforcement have been examined extensively in the literature. With regard to feedback, findings contrasting schedules of reinforcement have generally yielded nonsignificant results. Two contrasting studies were Lublin's (1965) investigation that found that

no feedback > variable feedback > fixed feedbackback >
correct answer after every item

and Krumboltz and Keisler (1965) who found that low ratios of feedback, such as for 10% or 20% of the items resulted in lower performance than higher ratios, such as 50% or 100%. It might be profitable to examine these findings within information within information processing theory, perhaps explaining the results as effects of learners' expectations or level of effort.

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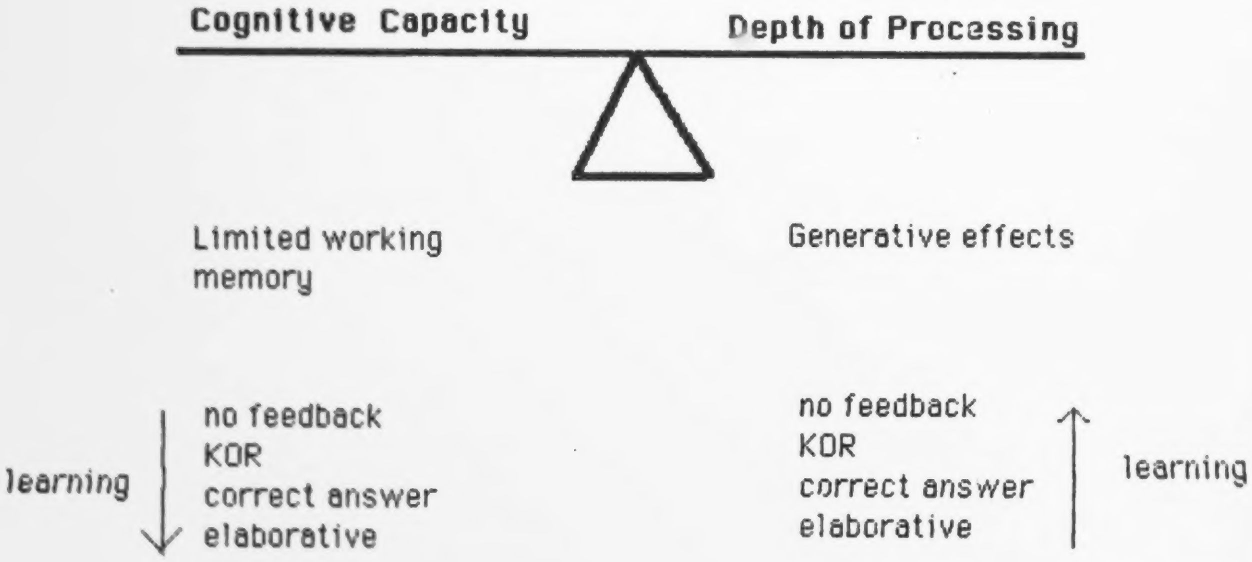
Figure 1. Model of Variables in Complex Interactions.

Task X Event X Feedback Variable X Learner Characteristic = Performance Measure

Figure 2. Model of counterbalancing processes


Cognitive Capacity
Depth of Processing
Limited working memory
Generative effects
learning
no feedback
KOR
correct answer
elaborative
no feedback
KOR
correct answer
elaborative
learning

Taxonomy of Content

Content	The content of feedback refers to the composition of the information provided to a learner after his/her response to a question within an instructional sequence.
Motivational	Motivational, reinforcing, feedback is information, which may include praise or other rewards, that follows a correct response.
Informational	Informational, often corrective feedback, is information that is provided to learners following their response to question within an instructional sequence.
• **No feedback**	This category of feedback is obvious. Instructional treatments that contain no feedback do not provide information either implicitly or explicitly about the accuracy of response or explanation of correct
• **KOR**	Feedback of this type tells learners, either explicitly or implicitly, whether their responses are correct or incorrect. or incorrect responses.
• **Correct answer**	This form of feedback informs learners of the correct answer to the question they have just answered.
• **Elaborative**	Elaborative feedback includes those more complex forms of feedback that explain, direct, or monitor. It may or may not be used in conjunction with KOR or correct answer feedback.
Explanatory	This category includes feedback that explains why a correct answer is correct and/or why an incorrect question is incorrect.

Directive	Directive feedback may cue or prompt learners as to strategies to determine the correct answer
Monitoring	Monitoring feedback, sometimes called advisement, provides learners with information as to how well they are performing in the lesson.

Taxonomy of Scheduling

Sceduling	This dimension refers to the decisions as to **how often** feedback will be provided to learners within an instructional sequence.
• Item by item	Feedback presented after each item or each item.
• Percentage Scheduling	Feedback on a percentage schedule provides feedback for only a certain percentage of the items (e.g., 20%, 40%, etc). Feedback **may** be **randomly** apportioned according to this percentage, or on a **fixed** schedule (e.g., after every third item).
• Cumulative	Feedback of this type generally presents cumulative information after a learner has answered a set number of items correctly or incorrectly (e.g., "Good you gotten 6 items correct.")

Title:

Towards a Theory of Instructional Text Design

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Paper presented at the annual convention of the Association for Educational Communication and Technology, New Orleans, January 1988

Towards a theory of instructional text design

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Introduction

Perhaps it is because text is such a ubiquitous part of the teaching/learning environment that those who use it for instruction appear to do so without any consideration for its design to facilitate learning. Yet it cannot be assumed, as Cunningham *et al* (1981) have pointed out, that meaning lies on a page and must somehow be lifted from the page into the mind of the reader. It is clear, rather, that the way text is comprehended and remembered is a function of both the structure of the text and the knowledge utilised by the individual (Voss & Bisanz, 1985). In approaching the design of text as an instructional medium, therefore, the instructional designer or instructional materials developer has to have a clear understanding of the process of reading comprehension and the variables in both the reader and the text which can affect that process (Stewart, 1987).

Reading comprehension is an interactive process between text-based ideas and reader-based schemata where the greater the correspondence between the text and the prior knowledge of the reader the more efficient will be the comprehension (Stewart, 1986). Individual differences in reading performance can arise from factors in bottom-up (or text-based) processing, top-down (or knowledge-based) processing, the interaction of top-down and bottom-up processing, and the metacognitive control processes that manage the entire system (Spiro & Myers, 1984). Purpose, world knowledge, cognitive and metacognitve skills, and imagery ability have been identified as some of the inherent characteristics of the reader which have to be taken into consideration by the instructional designer or instructional materials developer (Stewart, 1986), although they cannot be controlled by the designer. Control can, however, be exerted over design aspects of the text such that they can be manipulated within a framework of identified principles in order to facilitate comprehension. Understanding of these principles should enable the instructional designer/developer either to work from first principles to develop acceptable practice or to examine current practice against the criteria of identified principles and a theory of instructional text design to which they contribute.

The bases for a theory

There is, at present, no single theory of learning from text which would enable the outlining of a theory of instructional text design. What exists is a number of theories relating to how people learn from text, the most fundamental of which are those emanating from cognitive psychology regarding the interactive nature of the reading process and the structured and organised nature of knowledge in memory. These, of themselves, do not constitute a theory of instructional text design but they do provide a focus on which such a theory can be built. Stewart (1986) has identified areas of design concern - legibility & readability, visual illustration, and structure & organisation - and has derived principles in relation to these areas, with particular relevance to the cognitive psychology theories mentioned above, in an attempt to determine ways in which there could be a contribution to the structured and organised nature of knowledge acquisition within a framework of the interactive nature of the reading process. Each area of design concern was considered as contributing either to the 'interactivity' of the process or to the structure & organisation aspect of acquired knowledge in memory. A unifying theory can be developed from these considerations in which it is clear that, since, (a) reading is an interactive process between reader and text, (b) the process is contributed to by characteristics of both the text and the reader, and (c) knowledge in memory is highly structured and organised, design elements of the text can be manipulated to ensure that existing knowledge in the reader can be activated so that new knowledge presented in the text in a structured and organised way and appropriately highlighted through verbal and typographic cueing supported, as required, by visual illustration and organisation can be assimilated in a manner facilitative of comprehension.

Before outlining the nature of the emerging theory it is appropriate to consider the contribution to that theory from the identified areas of design concern.

Structure & organization

Winne (1985) has noted that information in permanent memory is highly organised and can be pictured as a complex network or a hierarchical array, with three basic forms of information being theorised - concepts, propositions, and schema. Not only are the forms of information organised; they achieve meaning by their relationships to one another. Brandt (1978) has argued that the content and structure of passages of text are inextricably linked and that students will learn better from text if they can follow the organisation of the material and later use that organisation. Glynn & Britton (1984) have suggested that, since comprehension of text can be a cognitively demanding task, authors can help readers to comprehend and recall text information by making sure that the design of their text supports each of the component comprehension processes that the readers must perform, including, *inter alia*, identifying the important ideas in the text, organising those ideas, and integrating them with prior knowledge.

Armbruster & Anderson (1985) found that, before text organisation became clear to them, it was necessary to analyse the underlying organisation of the content of the material. This emphasis on content analysis should hardly be surprising for the designer of instructional text since a prerequisite to the design of instructional materials must necessarily be a task or topic analysis. What is needed is, in essence, an analysis of a topic to find the logical heirarchical relations in the topic so that instruction can be sequenced accordingly (Tiemann & Markle, 1985). The first step within the structure & organisation area of design concern must, therefore, be the carrying out of a topic analysis.

Such a topic analysis not only clarifies the hierarchic relationships within the topic, but provides the basis for identifying the desired learning outcomes or objectives. Glynn et al (1985) have indicated that the organisation of text can be made explicit through both verbal and typographical cueing systems. It has been postulated by Stewart (1986) that the statement of a high-level learning outcome as an objective in advance of reading will lead the reader to adopt a "deep approach" (Dahlgren, 1984) to the reading of the passage. Since such an outcome can also be achieved by the insertion in text of higher-level questions, it is suggested that, in practice the high-level learning outcome can be stated in advance of the passage of text and high-level questions related to the stated learning outcome can be included within the text. Thus, the clarification of learning outcomes or objectives enables the instructional designer/developer to decide what kind of verbal cueing or pre-instructional strategy can be used to help the reader to recognise the desired outcome and adopt an appropriate approach to the reading task. It also allows the designer to give consideration to the formulation of the in-text questions of an appropriate type and level.

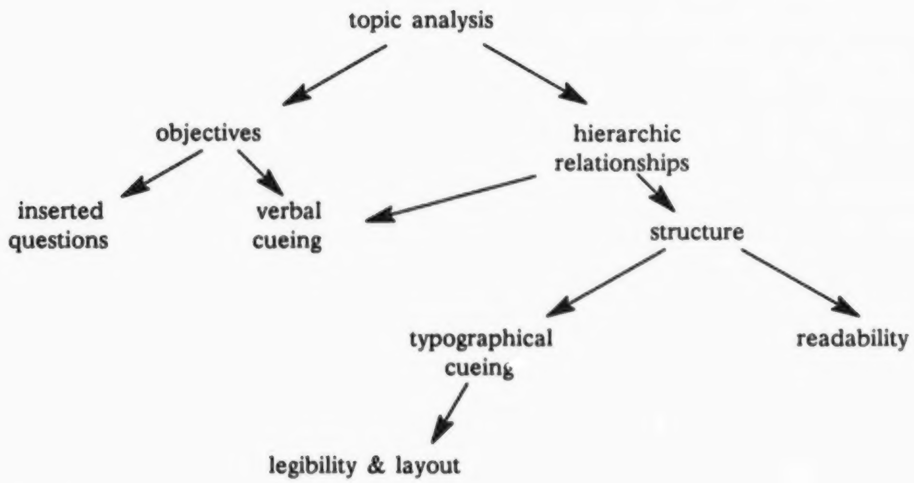
The topic analysis exercise, in clarifying the hierarchic relationship, enables the instructional designer or instructional materials developer also to consider the kind of verbal cueing necessary in relation to any advance organizer which must reflect the structure & organisation of the text and alert the reader to relevant schema-activation. Stewart (1986) has suggested the principle that, if the reader is oriented by a brief verbal organizer toward the application of existing knowledge to the assimilation of the main features of new knowledge in text, comprehension of that new knowledge will be facilitated. Application of this principle requires an emphasis on the activation of existing knowledge which is really guidance to the reader and is an extension or broadening of the concept of advance organizer.

The verbal cueing arising from the topic analysis thus allows an integration of learning outcome and overview of structure together with schema activation and establishment of a deep-approach set to learn.

Clarification of the hierarchic relationship provides, additionally, the basis for the determination of the structure of the text and from that can be developed the verbal and typographical cueing necessary to make explicit the structure. It is clear from the work of Singer (1985) and Meyer (1981, 1985) that there are organisational features of text which, if recognised and used by students, can lead to better process and recall of information, and Stewart (1986) proposed a principle of textual structure & organisation which deduced that, if the critical information to be communicated is appropriately emphasised as part of an overall text structure, comprehension will be facilitated. Application of this principle, while being ostensibly linguistic or psycholinguistic in nature, has implications for instructional design, in that instructional designers or instructional materials developers need to be concerned with linguistic factors, a skill not necessarily expected to be part of the instructional design armoury.

In analysing the research on typographical cueing, Stewart (1986) was able to suggest the principle that, if headings in text are chosen and arranged spatially and typographically to reflect the structural relationships in the text, comprehension of both the structure and the content of the text is likely to be enhanced. It is not often in an instructional text that the headings are arranged either spatially or typographically to reflect the structural relationship of ideas in the text. What is needed in practice is a greater correspondence betweeen the conceptual map and the typographical organisation of headings, a bringing together of notions of verbal and visual cueing allied with typography to help the reader comprehend both the structure and the content of the text. The starting point is the topic analysis: the end is a contribution not only to comprehension but to legibility, layout and readability.

Several areas of design concern are clearly brought together through consideration of the topic analysis as can be seen in the following illustration.



It should be noted, additionally, that consideration of structure and organisation issues also raises the questions of whether graphic organizers should be used and whether encouragement to the reader to utilise imagery abilities is appropriate. Two principles enunciated by Stewart (1986) are relevant.

> "If a graphic organizer is used to convey isomorphically the structure of ideas in text, then comprehension of the structure will be facilitated".
>
> "If the content of the text is related to spatial, creative, or problem-solving applications, the eliciting of imagery processes in its comprehension will be helpful".

Visual illustration

The second area of design concern which the instructional designer or instructional materials developer needs to consider is that of visual illustration. The observation by Perkins (1980) that practical picture making is a matter of recipe rather that principle is, unfortunately, too often correct in education. The basic misunderstanding of the use of visuals in learning probably lies in a belief that the message is in the visual. It has to be recognised that the message is not in the visual alone: the message is constructed in an interaction between the visual stimuli and the prior knowledge etc of the viewer. In education, too great an emphasis has been placed on the role of the visual and too little on the internal processing of the viewer (Winn, 1982; Salomon, 1979).

Duchastel's (1978, 1981) notion of attentional, explicative, and retentional functions of illustration appears to be well founded in the available theories of cognitive and visual processing systems, and is consistent with those of Levin (1979, 1981) and Levie & Lentz (1982). The idea that illustrations attract attention to materials is, intuitively, acceptable, although it would be more persuasive if it established that illustrations were the initial focus of attention. There is a real sense in which the text as a whole can either attract or repel, a feature which is related to congeniality, and it is very likely that illustrations play an important role in this respect. Great use is made of explicative illustrations in instructional texts, teaching directly, explaining and clarifying, but the retentional role of illustrations tends not to be so widely considered, yet, as Duchastel (1981) has pointed out, any topic or domain of discourse has an internal structure which can be exploited in visual terms for the purpose of recall.

The instructional designer needs to be clear about the function to be performed by the illustration. Duchastel's (1980) reminder that it is the type of illustration and its relationship with the verbal component of the text which will make it useful or not, is a crucial consideration.

After reviewing the available research on visual illustration in text, Stewart (1986) proposed the following principles.

> "If illustrations are developed as an intergral part of the text design they will perform a motivational or attention-getting function".
>
> "If illustrations are designed to support organisational or conceptual aspects of a topic in text, they will facilitate comprehension".
>
> "If illustrations are developed to support the verbal argument of text, the integrity of the text will be enhanced if the illustrations are appropriately embedded, and alluded to, in the text".

Implementation of these principles requires the instructional developer to integrate text and visual development and to justify to printers or publishers why particular visual images not only need to be presented in a specified way but be included adjacent to identified parts of text. The relationship between words and pictures within the context of the structure & organisation of the text is what is at issue and the use of visuals in text cannot, therefore, be left to the discretion of editors, illustrators, or anyone other than the person with overall control of the text design process.

Readability, legibility and layout

Having given consideration to the structure and organisation aspects, together with the aspects associated with visual illustration, the instructional designer or instructional developer has to prepare the textual material, taking into consideration not only those linguistic aspects of text which enable idea units to be highlighted within the overall indication of structure, but the linguistic aspects which influence the affective and cognitive dimensions of readability.

Despite the widespread criticism associated with readability research due, almost entirely, to the misuse of and extravagant claims for readability indices, readability remains an important issue in the design of instructional text. From an analysis of research in the area of readability, Stewart (1986) has highlighted the relationship between readability and motivation, claiming that initial motivation can be heightened through the design of text which is, in an affective sense, 'readable', and that readability will, in turn, be improved because of the increased motivation. Considerable attention needs to be directed, therefore, to those aspects of the text which contribute to its affective dimension, such as typestyle and layout. The affective aspect of readability can, potentially, induce emotional and motivational factors which are crucial to the arousing of interest and the focusing of attention which, in turn, are prerequisite to the facilitation of comprehension.

There is, too, a cognitive dimension to readability. A cognitive psychology framework for an understanding of the comprehension process and, thus, for readability, emphasises the psycholinguistic aspects of text as well as the reader-based sources of variance (Huckin, 1983; Chall, 1984). Stewart (1986) has suggested two principles of readability, viz

> "If the semantic and syntactic structure of the text is matched to the vocabulary and reading ability of the reader, there is more likely to be meaningful interaction between reader and text".
>
> "If the content and the psycholinguistic organisation of a text are related to the prior knowledge and cognitive ability of the reader, the readability of the text will be enhanced".

These two principles raise problems for educational practice due to the connection of content and style with reader ability and prior knowledge. Print is essentially a mass medium, yet these principles demand a considerable measure of individualisation. The application of these principles is probably best carried out by careful consideration of the group of readers for whom the material is being prepared, assessing as accurately as possible the abilities and prior knowledge which they have.

The designer/developer has to ensure, therefore, that the adopted style and the overall appearance of the material arising from the readability and layout considerations are conducive to the cultivation of motivation and, thus, comprehension.

Specific criteria of legibility becomes the final check with respect to physical parameters of the text to ensure that in the denoting of structure the typographical cueing is consistent with the other aspects of typography which, together, contribute to a well designed text.

Principles of legibility identified by Stewart (1986) and derived in relation to typeface, typestyle, size of type, length of line and interlinear spacing, and justification, arise primarily from text-based parameters and are affected only marginally by the input of the reader. However, although the use of typographical characteristics to affect layout is determined, in part, by physical parameters, there is also a potential contribution in respect of their cueing capacity. Relevant principles identified by Stewart (1986) are:

> "If the layout of a page is determined by the empirical evidence regarding typographic characteristics, the page will be more legible than if these characteristics are ignored".
>
> "If the typographic arrangement reflects the key features of the content of the text, comprehension of the structure of the text will be facilitated".

Since it is unreasonable to expect typesetters or printers to be able to analyse content and indentify key features, typographical cueing needs to be determined by the author or designer of the instructional text, so it is important that such persons be familiar with typography and its manner of specification.

The emerging theory

From the discussion above, it is clear that the emerging theory of instructional text design involves:

(a) a topic analysis to determine the hierarchic relationship of ideas within the topic and the desired learning outcomes or objectives, from which can be determined

  (i) the kind of verbal cueing or pre-instructional strategy necessary to enable the reader to recognise the desired outcome and adopt an appropriate approach to the reading task;

  (ii) the kind of verbal cueing, reflective of the structure and organisation of the text, necessary for relevant schema activation;

  (iii) the basis for the structure of the text and, thus, the typographical cueing necessary to make the structure explicit; and

  (iv) the kind of questions which can be inserted in the text;

(b) a consideration of the linguistic aspects of text which

  (i) enable idea units to be highlighted within the overall indication of structure;

  (ii) influence the affective and cognitive dimensions of readability;

(c) a consideration of the role of visual illustrations as to whether they are

  (i) motivational, explicative, or retentional in intent;

  (ii) indicative of spatial relationships in the text; and

(d) a consideration of the physical parameters of the text to ensure that, in the denoting of structure, the typographical cueing is consistent with the other aspects of typography.

Although not particularly important, it can be noted that the issues (a)-(d) are, respectively, the design areas of structure & organisation, readability, visual illustration, and legibility, the resulting acronym for which - SORVIL - might usefully identify this approach to a theory of instructional text design.

It is not claimed that this is a complete theory of instructional text design, but it is offered as a contribution to such a theory. There could be other inter-relationships between the identified areas of design concern which need to be explored and there may well be other design areas which need to be taken into consideration.

The instructional designer/developer, in approaching the design of text, would normally develop the material in accordance with accepted instructional design procedures consistent with, for example, an educational technology approach to the design of instruction. However, as Stewart (1985) has alleged, the principles of educational technology are not always explicit and there is a tendency for instructional designers or instructional media developers to adopt established procedures and practices without, necessarily, being able to justify these practices from more fundamental principles of educational technology. It is therefore likely that, in the development of instructional text, the same approach is being adopted.

In moving towards a theory of instructional text design which is based firmly on valid principles, it is hoped that instructional designers and instructional materials developers will, in the application of that theory, measure practice against principle and allow principle to determine practice.

As Carter (1985) has observed,

> ". . . the problem of producing usable written materials may have less to do with discovering a host of new principles than with learning to routinely apply these we already know". (p156)

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Title:

Instructional Design for the Improvement of Learning and Cognition

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Instructional Design for the Improvement of Learning and Cognition

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Paper presented in the symposium, "Using Alternative Designs for Conducting Research in Instructional Technology," Dean L. Christensen (Chair), annual meeting of the Association of Educational Communications and Technology, New Orleans, January 1988.

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Instructional Design for the Improvement of Learning and Cognition

The purpose of this paper is to present a cognitive-science based instructional planning and design model that deals directly with the educational goals of both knowledge acquisition (i.e., learning) and employment (i.e., cognition). The model describes the direct relationship between specific cognitive-based objectives and instructional methods. Within this context, we follow Gagne's (1985) premise that unique instructional methods directly improve specific learning and thinking processes. Thus, we propose an instructional planning and design model by which to link cognitive processes and objectives to specific instructional methods. An additional feature of our planning and design model is the direct reference to instructional time allocations for each cognitive-based objective (see Figure 1).

Instructional Planning and Design Model

In this paper we present a basic model for planning the learning environment that proposes application of cognitive learning theory with specific instructional methods (Figure 1). In other sources are presented the empirical findings that support the instructional methods in terms of their affect in improving learning and cognition (for a review of the empirical findings see Tennyson & Breuer, 1984; Tennyson & Cocchirella, 1986; Tennyson, Thurlow, & Breuer, 1988). Our purpose in this paper is to propose an instructional design model that focuses on the planning of a learning environment so that students not only acquire knowledge but also improve their cognitive abilities to employ and extend their knowledge.

Insert Figure 1 about here

Educational leaders have recently renewed their call for planning of learning environments that exhibit, in addition to acquisition of information (or content), the learning of higher-order thinking strategies (e.g., Savell, Twohig, & Rachford, 1986) and the development cognitive abilities. However, two major problems persist in the implementing of such goals. The first is the continuing assumption that appropriate instructional methods are not available. And, second, that improvement in cognition occurs through some independent system external to the mainstream curricular programs. For example, that thinking skills can be acquired through the practice of generic strategies and then latter transferred across any domain of information (i.e., Feuerstein, Rand, Hoffman, & Miller, 1980). However, our thesis here is that both problems can be solved.

First, educational research in the past two decades has investigated instructional variables and conditions that show dramatic improvements in both knowledge acquisition and employment (Reiser, 1987). Thus, it is possible to define in concrete terms instructional methods that can improve both cognitive goals.

LEARNING ENVIRONMENT

	ACQUISITION OF KNOWLEDGE BASE (Storage)			Employment & Improvement of Knowledge Base (Retrieval)	
LEARNING TIMES	10%	20%	25%	30%	15%
COGNITIVE-BASED OBJECTIVES	VERBAL INFORMATION	INTELLECTUAL SKILLS	CONDITIONAL INFORMATION	THINKING STRATEGIES	CREATIVITY
MEMORY SYSTEMS	DECLARATIVE KNOWLEDGE	PROCEDURAL KNOWLEDGE	CONCEPTUAL KNOWLEDGE	COGNITIVE COMPLEXITY	TOTAL COGNITIVE SYSTEM
INSTRUCTIONAL STRATEGIES	DRILL & PRACTICE METHODS	TUTORIAL METHODS	TASK-ORIENTED SIMULATIONS	PROBLEM-ORIENTED SIMULATIONS	SELF DIRECTED EXPERIENCE

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Second, research findings strongly indicate that higher-order thinking strategies are best learned within the context of conventional subject matters (Resnick, 1981). That is, panaceas with quick-study, domain-independent methods do not provide the conceptual knowledge necessary to improve accessibility of information in the knowledge base. Although research continues on instructional variables and strategies, there are currently available instructional methods that can immediately meet the educational goals of improving both knowledge acquisition and employment (Gagne, 1987).

A key factor in implementing the cognitive goals of knowledge acquisition and employment is the allocation of learning time with instructional methods within a curricular context (See Kulik & Kulik, 1984, for a review on performance and instructional time). For example, Goodlad (1984) suggested, from his research findings on classroom time and instructional activities, that a significant change in instructional time allocated to various learning activities must be done if improvements in problem solving and creativity were to occur. He recommended that the conventional instructional time allocation for learning be altered so that, instead of 70% of instruction be aimed at the declarative and procedural knowledge levels of learning, 70% be devoted to learning and thinking situations that involve acquisition of conceptual knowledge and development of cognitive abilities. And, that these instructional situations be done within the subject matter areas, not external to them.

Using Goodlad's recommended figures on instructional time allocation, we propose that 70% of formal, classroom learning time use instructional methods that focus on higher-order learning and cognition. In Figure 1, we present an instructional planning model of the learning environment that shows the direct relationships between learning time, cognitive objectives, memory systems components, and instructional strategies. Figure 1 shows a time allocation guideline for curriculum planning such that the goals of knowledge acquisition and employment can be traced between cognitive objectives and specify instructional methods.

Memory Systems

The acquisition of information and the means to employ information occurs within the storage and retrieval subsystems of the long-term memory component (Tennyson & Breuer, 1984). The storage system is where coded information is assimilated into the existing knowledge base. A knowledge base can be described as an associative network of concepts (or schemas) varying per individual according to amount, organization, and accessibility of its information (Rabinowitz & Glaser, 1985): amount refers to the actual volume of information coded in memory, while organization implies the structural connections of that information, with accessibility referring to the executive control strategies used in the service of thinking (i.e., recall, problem solving, and creativity). The latter two forms of knowledge are those that separate an expert from the novice. That is, a large amount of information is not the key to expert thinking, but rather the ability to both find and employ information appropriately.

Within storage there are various forms of knowledge: declarative, procedural, and conceptual (Shiffrin & Dumais, 1981). Each form represents a different memory system or function. Declarative knowledge implies an awareness of information and refers to the "knowing that," for example, that underlining keywords in a text will help recall. Procedural knowledge implies a "knowing how" to use given concepts, rules, and principles. Conceptual knowledge implies an understanding of "knowing when and why" to select specific concepts, rules, and principles. This executive control process of knowing when and why, is governed by selection criteria embedded within the organization of the knowledge base. Criteria are the values and situational appropriateness by which connections within the schematic structure of a knowledge base are made. Whereas both declarative and procedural knowledge form the amount of information in a knowledge base, conceptual knowledge forms its organization and accessibility.

The retrieval system employs the cognitive abilities of differentiation (i.e., selection) and integration (i.e., restructuring) in the service of thinking strategies associated with recall, problem solving, and creativity. Recall strategies employ only the automatic selection (i.e., differentiation) of knowledge directly as stored in memory. Problem solving strategies, on the other hand, require both cognitive abilities of differentiation and integration and are formed at the time of solution and stored as conceptual knowledge. That is, problem solving strategies are domain specific and cannot be considered as generic "skills" that can be transferred between domains. Therefore, the accumulation of problem solving strategies in the knowledge base occurs in direct reference to number of problems solved within given domains. Creativity strategies, in addition to employing differentiation and integration, make use of the cognitive ability to create knowledge not already coded in memory (Dehen & Schank, 1982).

In summary, all three kinds of thinking strategies are acquired while using the cognitive abilities of differentiation, integration, and creation. Each strategy form is embedded by domain within the conceptual knowledge structure of the knowledge base. Therefore, as the learner engages in more thinking situations, the individual strategies become increasingly more abstract and generalizable within the domain (Sternberg, 1985).

Cognitive Complexity.

As stated above, thinking strategies employ the three cognitive abilities of differentiation, integration, and creation of knowledge. The first two abilities occur primarily in the retrieval system of memory while the third further involves the other components of the entire cognitive system (see Figure 1).

The operational term for the retrieval system functions of differentiation and integration is cognitive complexity (Schroder, 1971). Cognitive complexity, as contrasted to intelligence, is an ability that can be developed and improved (Streufert & Swezey, 1986). Differentiation is defined as follows: (a) the ability to understand a given situation; and (b) the ability to apply appropriate conceptual criteria (i.e., the standards, situational appropriateness, and/or values) by which to select necessary knowledge from storage. Integration is the ability to elaborate or restructure existing knowledge in the service of the given problem situation. Creativity is the ability to form new declarative and procedural knowledge as well as conceptual knowledge by using the total cognitive system.

Learning Time

The allocation of learning time is divided between the two main subsystems of long-time memory--storage and retrieval. Within the guidelines illustrated in Figure 1, time is assigned according to the memory systems defined in the previous section. In the storage system, learning time is allocated among the three memory systems making up a knowledge base as follows: declarative knowledge 10%; procedure knowledge 20%; and conceptual knowledge 25%. We are recommending that conceptual knowledge learning time be about equal to the other two knowledge forms because of the necessity in acquiring information to both organize a knowledge base and develop accessibility. The value of a knowledge base is primarily in the functionality of its organization and accessibility. Without a sufficient base of conceptual knowledge, the opportunity for employment, future elaboration, and extension of the knowledge base is severely limited (for example, see Bransford & Johnson, 1972; Brown, 1978; Rohwer, 1975).

For the knowledge acquisition goal, the focus of our learning time allocation is on conceptual knowledge, and away from the usual practice of heavy emphasis on amount of information. We are assuming that content knowledge acquisition is an interactive process that is improved when employing the knowledge base in the service of higher-order thinking situations (i.e., problem solving and creativity). Time allocated for declarative and procedural knowledge focuses on establishing an initial base of necessary content knowledge that can be used within a context of a problem situation. That is, learning time should include the opportunity for the learner to gain experience in employing the knowledge.

The learning times presented in Figure 1 do not imply a linear sequence of knowledge acquisition going from declarative to conceptual. Rather, they represent total amounts in an iterative learning environment where learners are continuously acquiring each form of knowledge. For example, students may engage in conceptual knowledge acquisition prior to declarative knowledge acquisition if they currently have sufficient background knowledge (i.e., a discovery method of instruction as contrasted to a structured method).

Cognitive-based Objectives

The purpose of cognitive-based objectives is to further elaborate the curricular goals of knowledge acquisition and employment. Objectives are important in the planning of learning environments because they provide the means of both allocating learning time and identifying specific instructional methods. Also, unlike behavioral objectives which only state measurable desired end of instruction outcomes, cognitive-based objectives imply a given cognitive process of learning or thinking.

In terms of learner assessment, the cognitive-based objectives that deal directly with the acquisition of declarative and procedural knowledge (see Figure 1) provide for quantitative measures of specific domain information. However, the cognitive-based objectives for conceptual knowledge acquisition and improvements in thinking are more subject to reflective evaluations rather than the usual correct or incorrect assessments associated with the learning of content information. That is, it is far easier to test a knowledge base for amount of information than it is to measure the organization and accessibility.

The cognitive-based objectives presented here are for the most part taken from Gagne's (1985) classification of learning outcomes. Whereas Gagne prefers to lump all thinking processes into one category of human capability (i.e., cognitive strategies), we prefer a system of objectives that provides for more basic distinctions between the various forms of thinking. This allows for improved clarification of both instructional outcomes and methods. Thus, there is a direct trace between memory system components and objectives and learning time. We define cognitive-based objectives as follows:

-Verbal information. This objective deals with the learner acquiring an awareness and understanding of the concepts, rules, and principles within a specified domain of information (i.e., declarative knowledge). The specific concepts to be learned is identified by an information analysis procedure that shows the schematic organization of the domain as well as the individual concepts. An analysis of the information to be learned is a highly important procedure in instructional design because it provides the instructional sequence by which information can be presented. That is, a structured sequence enhances the learner's initial organization of a knowledge base see Tennyson, 1981, for a complete review of an information analysis).

-Intellectual skills. This objective involves the learner acquiring the skill to correctly use the concepts, rules, and principles of a specified domain of information (i.e., procedural knowledge). For example, the classification of unencountered examples of a given concept. Classification is the intellectual skill by which learners to both discriminate and generalize unencountered examples. The intellectual skill for a rule, is the ability to use the rule correctly in the solving of an unencountered problem.

-Conditional information. This objective focuses on the learner's acquisition of a knowledge base's organization and accessibility (i.e., conceptual knowledge). The organization of a knowledge base refers to the schematic structure of the information whereas the accessibility refers to the executive control strategies that provide the means necessary to employ the knowledge base in the service of recall, problem solving, and creativity. Conceptual knowledge includes the criteria, values, and appropriateness of a given domains schematic structure. For example, simply knowing how to classify examples or knowing how to use a rule (or principle) does not imply that the learner knows when and why to employ specific concepts or rules. Therefore, this objective defines a learning environment where the learner can develop both the associative network of the knowledge base (i.e. organization) and the control strategies to effectively employ the knowledge (i.e., accessibility).

-Thinking strategies. This objective deals with both the development of cognitive complexity abilities and the improvement of domain specific strategies of thinking. Thus, this category of cognitive-based objectives deals with two important issues in education. First, the elaboration of thinking strategies that will arm the students with increased domain specific conceptual knowledge. As stated earlier, thinking strategies are domain-dependent and are only transferable between domains at the most abstract levels of possible employment. For example, knowing the scientific method of inquiry does not in and of itself provide sufficient information to transfer across disciplines without the further acquisition of more concrete domain-dependent application concepts. Second, the development of the cognitive abilities of differentiation and integration. These abilities provide the cognitive tools to effectively employ and improve the knowledge base; therefore, they are integral to any educational goal seeking to improve thinking strategies.

-Creativity. This objective deals directly with the most elusive goal of education, and that is, the development and improvement of creativity. We defined creativity as a two fold ability: First, creating knowledge to solve a problem from the external environment; and, second, creating the problem as well as the knowledge. Integral to the creating of both the problem and knowledge is the criteria by which consistent judgement can be made. Again, we define two forms of criteria. The first is criteria that are known and which can be applied with a high level of consistency. In contrast are criteria that are developed concurrently with the problem and/or knowledge, and is consistently applied across a high level of productivity. Creativity objectives need to specify not only the ability to develope and improve, but also the form of criteria. That is, students should be informed of the criteria in the former and, in the latter, the necessity to develop criteria.

Instructional Methods

In this section, we identify instructional methods that have direct relationships to specific cognitive-based objectives. Also, these methods (or strategies) are composed of instructional variables that have rich empirical-bases of support. That is, instead of prescribing a given strategy of instruction for all forms of learning, we have identified general categories of strategies, each composed of variables that can be manipulated according to given instructional situations.

The five instructional categories are as follows:

Drill and practice. This category represents those instructional strategies designed to provide a practice environment for learning declarative knowledge. The two basic instructional forms of practice within this category are worked examples and question/problem repetition. These in turn can be further elaborated by various forms of branching and ratio repetition between correct and incorrect patterns of response (see Salisbury, 1988, for a complete review of drill and practice strategies).

Worked examples is a practice environment in which the information is presented to the student in an expository form. The purpose is to help the student in understanding both the context of the information and the structure of information (i.e., organization). For example, to learn a mathematical operation, the student is presented the steps of the process in an expository problem concurrently, presenting explanations for each step. In this way, the student can clearly understand the procedures of the mathematical operation without developing possible misconceptions often occurring with discovery methods of teaching (Petkovich & Tennyson, in press).

The question/problem strategy presents selected information repeatedly until the student answers or solves all items at some predetermined level of proficiency. The purpose here is to efficiently acquire the amount of information in a knowledge base. Differences in question/problem strategies come from the manipulation of the ratio between correct and incorrect responses. Context is important here because of the students background knowledge can determine whether massed practice is better than variable. If a student, for example, has good background knowledge, massed practice may be more efficient because of an existing organized knowledge base. On the other hand, if the student does not have background knowledge in which to elaborate, variable practice may be better because the student needs to develop some organizational context for the information in addition to just the amount of information.

Tutorials. This category of instructional strategies contains a rich variety of variables and conditions to manipulate to improve learning. This category is labelled tutorial because the objective is to learn how to use knowledge correctly, therefore, it requires constant intervention between student application (e.g., problem solving) and instructional system monitoring. Tutorial strategies attempt to create an environment where the student learns to apply knowledge to unencountered situations while being carefully monitored so as to both prevent and correct possible misconceptions of procedural knowledge.

The basic instructional variable in this strategy is the presentation of interrogatory (question) problems that have not been previously encountered (see Tennyson & Cocchiarella, 1986, for a complete review of variables in this category). Other variables include means for evaluation of learner responses (e.g., pattern recognition), advisement (or coaching), elaboration of basic information, organization of information, number of problems, use of expository information, error analysis, and lastly, refreshment and remediation of prerequisite information (Tennyson & Christensen, 1988). In schooling environments, peer tutoring has been shown to improve learning when tutors are trained with the above variables and are matched intellectually with the tutee. More recently, computer-based tutorial systems have employed advanced rule-based methods of programming to develop machine-intelligent applications of the above variables. Only the MAIS system has successfully employed more than one of the above variables in an intelligent computer-assisted instructional program (Tennyson & Park, 1987).

Task-oriented simulations. In the instructional planning model (see Figure 1), we propose that 25% of the instructional time be devoted to the acquisition of conceptual knowledge. The proposed instructional strategy for this category uses a simulation technique. The purpose of simulations is to improve the organization and accessibility of information within a knowledge base by presenting problems that require the student to search through their memory to locate and retrieve the appropriate knowledge to propose a solution. Within this context, the simulation is a problem rather than an expository demonstration of some situation or phenomenon.

In most discussions of knowledge base organizations, the specification of this accessibility process is elusive. However, in the field of artificial intelligence, the accessibility process is the most important function of an intelligent system. Within expert systems, conceptual knowledge is represented in the form of the search rules. These rules are often in the form of production rules (e.g., IF THEN statements) or higher-order, meta rules. More advanced AI systems use fuzzy logic rules or conditional probability hueristics to account for situations that require inferences that do not result in only dichotomous outcomes.

Human memory systems, however, unlike computer-based AI systems, can self-generate the conceptual knowledge of the knowledge base. The instructional key to improving this human cognitive process, is the opportunity for the learner to participate in solving domain-specific problems that have a meaningful context. Unlike problems in the tutorial strategies that focus on acquiring procedural knowledge, simulations in this category exhibit tasks that require employment of the domain's procedural knowledge. Thus, the student is in a problem solving situation that requires establishing connections and associations between the facts, concepts, rules, and principles of specific domains of information.

Task-oriented simulations present domain specific problem situations to improve the organization and accessibility of information within the knowledge base. Basically, the strategy focuses on the student trying to use their declarative and procedural knowledge in solving domain-specific problems. Task-oriented simulations present task situations that require the student to (a) analyze the problem, (b) work out a conceptualization of the problem, (c) define specific goals for coping with the problem, and (d) propose a solution or decision.

To help students acquire a richer schematic network for their knowledge base, cooperative learning group techniques become an integral component of the task-oriented simulation strategy. Within heterogeneous groups, students present and advocate their respective solutions to problems posed by the simulation. Research findings indicate that socialization is an important condition in the improvement of conceptual knowledge acquisition (e.g., Wagner & Sternberg, 1984). That is, the process of advocacy and controversy within the group provides an environment for students to both elaborate and extend their conceptual knowledge. In other words, task-oriented simulations add practical experience to the knowledge base not usually acquired until placed in a "real world" environment.

Problem-oriented simulations. Instructional methods for developing thinking strategies are often employed independent of the learners knowledge base. For example, Feuerstein, Rand, Hoffman, and Miller (1980) present an elaborate training program to teach thinking skills by having students practice problem solving methods with nonsense tasks. The assumption is, that after learning a set of generic, domain-independent problem solving skills, these skills can be transferred to domain specific situations. However, independently derived empirical findings of such training programs show little, if any transfer (Frederiksen, 1984). Part of the explanation for the failure of such transfer, is that when domain-specific instruction is given, the focus is on acquisition of declarative and procedural knowledge rather than either acquisition of conceptual knowledge or thinking strategy development. Also, given the complexity within the organization of a knowledge base, thinking skills do not provide sufficient means to cope with any but the most simplest of problems (Gagne & Glaser, 1987).

In contrast to the many training systems for domain-independent thinking skills development, simulations that present domain-specific problem situations, allow learners to develop their thinking strategies while employing the domain knowledge stored in their memory system. Problem-oriented simulations extend the format of the task-oriented simulations by use of an iterative problem format that not only shows the consequences of decisions but also updates the situational conditions and proceeds to make the next iteration more complex. That is, the simulation should be longitudinal, allowing for increasing difficulty of the situation as well as providing the adding and dropping of variables and conditions. In more sophisticated simulations these alterations and changes should be done according to individual differences. Instructional variables and conditions of a problem-oriented simulation are as following:

-Situations that have a meaningful context (i.e., not a game) that require the learners to use their own knowledge base;
-Complex situations to challenge the learners differentiation process;
-Situations that exposes learners to alternative solutions to improve their integration process;
-Situations in which learners see challenging alternatives within each learner's own level of cognitive complexity;
-Situations that learners view as environmentally meaningful to develop conceptual criteria;
-Situations that use reflective evaluation rather than right or wrong answers to develop learners higher-order conceptual criteria;
-Situations that allow for continuous development of higher-order thinking strategies;
-Situations that allow learners to see consequences of their solutions and decisions; and
-Situations that allow for predicting value of future states of the situation.

The main features of problem-oriented simulations are: (a) to present the initial variables and conditions of the situation; (b) to assess the learner's proposed solution; and (c) to establish the next iteration of the variables and conditions based on the cumulative efforts of the learner.

To further enhance the development and improvement of higher-order thinking strategies, we propose the employment of cooperative learning methods. Research findings (e.g., Breuer, 1985, 1987) indicate that intra-group interactions in problem-solving situations contribute to cognitive complexity development because the learners are confronted with the different interpretations of the given simulation conditions by the other group members. In this way, new integrations between existing concepts within and between schemata can be established, alternative integrations to a given situation can be detected, and criteria for judging their validity can be developed.

An important issue in cooperative learning is the procedure used to group students. Most often, when cooperative learning groups are used for knowledge acquisition, the students are organized according to heterogeneous variables, such as gender, socio-economic, intelligence and achievement. However, our research shows that for development of thinking strategies, group members should have similar abilities in cognitive complexity. That is, within groups, students should be confronted with solution proposals that are neither too much above or below their own levels of complexity.

For example, students with low cognitive complexity become frustrated and confused with highly sophisticated solutions, while students with high cognitive complexity are not only not challenged but become quickly bored with less sophisticated solutions.

The format of the group activity should employ a controversy method where a consensus is reached following a discussion of proposals independently developed and advocated by each member. This format is in contrast to the compliance method where a consensus is reached by members working together from the start.

The controversy method can be explained in the following example which uses a computer-management system:

1. The problem situation is presented to the students. The computer-based simulation prints out the initial conditions of the situation.
2. The students on an individual basis study the situation and prepare an independent proposal.
3. The students reassemble as a group to present their proposals. In the initial presentation, the students are to advocate their position.
4. Following the initial presentations, the students are to continue advocacy of their proposals in a debate fashion. The concept of the controversy method is used to help the students further elaborate their positions as well as seeing possible extensions and alternatives
5. The final goal of the group session is to prepare a cooperative proposal to input into the simulation. This consensus is reached only after a complete debate and should represent the group's "best" solution.
6. The computer program will then update the situation according to the variables and conditions of the simulation. The steps are then repeated until the completion of the simulation.

In summary, problem-oriented simulations are designed to provide a learning environment in which learners develop and improve higher-order thinking strategies by engaging in situations that require the employment of their knowledge base in the service of problem solving.

Self-directed experiences. Creativity seems to be a cognitive ability that can be improved by learners engaging in activities that require novel and valuable outcomes. As Gagne (1985) has often written, creativity can be improved by instructional methods that allow students the opportunity to create knowledge within the context of a given domain. Instructional programs that provide an environment for easy manipulation of new information increase the learning time available for such activities. An example of such an environment is LOGO (Papert, 1980), a computer-based software program within the domain of mathematics. LOGO is especially helpful for those students who currently have a good declarative and procedural knowledge base of mathematics and need to elaborate their organization and accessibility of that knowledge.

Other computer-based software programs provide environments for self-directed learning experiences that may improve creativity within given domains. For example, word processing programs have been shown to improve writing skills because of the ease in correcting and adjusting text structure (Lawler, 1985). Computer-based simulations have also shown that creativity can be improved when students can both continually see the outcomes of their decisions while understanding the predictability of their decisions.

Creativity seems to be a cognitive ability that can be improved with use within a domain, and that computer-based software programs seem to provide the type of environment which can enhance instructional methods for such improvements (Collins & Stevens, 1983). Because of the time necessary for participating in creative activities, educators should provide sufficient learning time for such development (Tennyson et. al., 1988). Computer software programs that are domain specific enhance the cost-effectiveness of instructional strategies aimed at the improvement of creativity.

The key instructional attribute for this category is an environment that allows students to experience creativity in at the moment "real" time. Computer software programs that are domain specific and allow for self-directed learning seem to offer the best instructional method for meeting goals of a curriculum that emphasizes higher-level thinking strategies.

Conclusion

The purpose of this paper was to present a model of the learning environment that directly allocates learning times with specific cognitive learning objectives and instructional methods. We proposed that learning time be allocated according to acquisition and employment of a learner's knowledge base. The emphasis of the model is that acquisition of conceptual knowledge and development and improvement of thinking strategies and creativity account for 70% of a learners formal learning time, and that the remaining time be allocated to acquisition of information. Because of the focus on conceptual knowledge and thinking strategies and creativity in relationship to domains of information, as contrast to learning information and thinking strategies as independent instructional methods, declarative and procedural knowledge would be further acquired by the process of elaboration and iteration provided in the instructional methods of simulations and self-directed experiences.

In conclusion, the learning environment model stresses that currently there exist sufficient instructional strategies to improve student learning in each of the areas of the learning/thinking processes. That is, although there needs to be continued research in variables and conditions of instruction, there are predictable instructional prescriptions available to now improve both learning and thinking. Also, we recognize that there are other goals of any educational curriculum not discussed in this model and that they need to be considered when designing a comprehensive curriculum. Our concern was to focus only on the variables and conditions of instruction for the improvement of knowledge acquisition and employment. The meta-learning model provided us with the opportunity to look at the whole range of learning objectives without the constraints of meeting the conditions of a given learning or instructional theory. It was within that context that we were able to define meta-instructional methods with prescribed learning times.

Our hope is that this instructional planning model will offer a baseline for further discussion on the important issue of instructional time and the improvement of learning.

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Title:

A CBI Model for the Design of CAI Software by Teachers/Nonprogrammers

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Martin Tessmer & David Jonassen AECT, 1988

A CBI MODEL FOR THE DESIGN OF CAI SOFTWARE BY TEACHERS/NONPROGRAMMERS

INTRODUCTION

This presentation describes the assumptions and methods of a CAI design process that teachers can use to design CAI software. The design model is intended to facilitate software design by teachers who may not know how to program a computer, but the model can be used by teacher-programmers as well. The model is intended for teachers at all levels, elementary, secondary, and postsecondary. The model has been field tested with secondary and postsecondary instructors as a textbook (Tessmer, Caverly, & Jonassen, in press) in the graduate teacher education program at the University of Colorado at Denver.

The textbook is a workbook that guides students through the design of a CAI lesson on paper. In this presentation, we would like to explain three components of this design model exemplified in this text: 1) the assumptions that underlie the instructional content and methods of the text, 2) the instructional methods themselves and 3) the results of our use of the workbook in a teacher training class.

To begin with, we would like to define several terms that will be used in this presentation:

1. "CAI Strategy". When we speak of a CAI strategy, we are speaking of ways a teacher can use the computer to facilitate learning of a given learning outcome. These methods include tutorials, drill and practice, simulations, games, and problem solving tools such as database management tools. These strategies may or may not involve stand-alone CAI instruction.

2. "Programming". We believe there are two types of CAI programming:

a) programming as coding, the more common definition of programming, involves entering the program commands into the computer,

b) programming as content and structure design, involves specifying the lesson content and structure in screen displays. In this second type of programming, the CAI program is created.

As we shall see, we assume that these programming types are not only conceptually but realistically distinct. Inotherwords, both types of programming can be done by the same or separate people for the same CAI lesson.

ASSUMPTIONS

The Role of Teachers in Software Design and Production

1. Teachers will continue to produce their own computer software. The quality of commercial CAI software is increasingly better, but teachers will still produce their own. This is because:

a) as with all media, some teachers prefer to "roll their own" regardless of the quality of available software and the time it takes,

b) there is still a large amount of poor quality software for many content areas (Schiffman, 1986; Smith, 1987),

c) computers are increasingly available to teachers at all levels of schooling,

d) more districtwide support is available for teachers to design software,

e) more teachers are becoming comfortable with computers and thus are willing to try developing CAI,

f) programming help for software development is increasingly available to teachers.

g) When teachers must code CAI themselves, the latest authoring systems (e.g. Course of Action) make it increasingly easier to code a CAI lesson.

2. Teachers should not have to code a computer to program it, they program it through the design of screen displays. Better software is produced when the teacher can spend time on the design of the CAI program on paper screen displays, which then can be given to a programmer for program coding. This allows the teacher to concentrate on the content and teaching methods of the program

(although programming knowledge is helpful). Screen displays are job aids that help teachers format the information properly. As Hazen (1985) indicates, good formatting has motivational as well as instructional properties. More important, screen displays guide the teachers into a frame-based approach to software design, an approach that is effective for a variety of CAI strategies (Bonner, 1987). Most important, using screen displays forces the teacher to design the program on paper before any coding is done, so that they pay attention to the content and methods of the instruction, improving the instructional validity of the product.

3. *In many school settings, teachers will function as the designers and subject matter experts of the program, but do not have to function as the program coders, and should not.* Several CAI designers recognize that the ideal software production team in education consists of a designer, teacher, and programmer (Collis & Gore, 1987; Smith, 1987). However, instructional designers are not readily available to most teachers, particularly at the elementary and secondary school level. On the other hand, programmers are becoming more prevalent, particularly at the secondary level, where students are more proficient programmers.

4. *In most school settings, instructional software will be utilized in situations where the teacher, students, media, and other resources are available to supplement the CAI lesson; the software does not usually function as a stand-alone lesson.* As Schiffman (1986) has indicated, teachers incorporate software within an overall teacher-designed lesson plan that can include a variety of off-screen activities in the lesson. These activities involve peer

consultation, worksheets, practice and testing, and teacher help.

Methods for Learning Software Design

1. Teachers best learn how to "program" a computer through a tutorial workbook approach. This approach allows them to gradually plan their lesson through workbook exercises in each chapter of the text, and then convert the exercises directly into screen displays for final coding. A workbook requires the student immediately applies what they have learned in a chapter to their own project, avoiding the mistake of the "now let's put it all together approaches" of books that merely describe CAI. These books require the novice to synthesize all that they gave learned at the very end of the book, or they just offer descriptive advice with no design activities whatsoever. Also in a workbook, teachers first devote their efforts exclusively to the design of the content and methods of the program and not to how to code it or even design it on screen displays. After teachers have designed a program once or twice in this manner, they can then use screen displays immediately for lesson design.

2. To design effective CAI, teachers need to learn a few basic instructional events that uniquely suit the both the learning outcome and CAI strategy they use. As Resnick (1976) has argued, learners can elaborate upon a skilled performance routine once they have mastered a basic routine. Although they are usually novice programmers, teachers have a repertoire of teaching techniques and strategies that they use in instruction. What they need to know are the essential instructional events for the given learning outcome and CAI strategy they teach. They will embellish these with their

own instructional events as they design the program. The mistake of many CAI design books is they try to teach too many design options and factors for a single type of approach; they overload the novice with detail and options, depending on the novice to "figure out" what they need for their lesson, or for a teacher to teach them. These books often do not allow the student to construct anything as part of the text activities, nor do they furnish any programming guidelines via job aids.

3. *Teachers should learn the general types of CAI strategies and the types of learning outcomes, which can be used to limit the range of possible CAI lesson features to those that suit both the strategy and outcome.* Teachers learn to apply this limited set of design options to create a CAI lesson, and to embellish them with their own teaching methods.

Program Characteristics of Effective CAI

1. *Effective CAI design is outcome-based.* The key to the teacher's selection of apropriate CAI lesson characteristics lies in their classification of the learning outcome(s) of that lesson. The learning outcome of a CAI lesson helps determine the lesson objectives, learner readiness activities, instructional content and methods, practice and test items, and formative evluation criteria. To classify outcomes, teachers learn to write objectives, conduct simple task analyses, and describe the characteristics of different learning outcomes.

2.*Effective CAI lessons embody a microstrategy (no pun intended) composed of instructional events that suit both the learning outcome and general CAI strategy selected by the teacher.* There are five basic types of CAI strategies (deductive/inductive tutorial, game, simulation, drill/practice, problem solving tools). Each has a different set of instructional events that are embodied in the program, depending upon the learning outcome of the instruction (concept learning, rule/principle learning, verbal information, problem solving). This actually creates a 5 x 4 matrix of types of CAI (Figure 1). This matrix approach elaborates upon the Gagne, Wager, and Rojas approach (1981), in that the CAI designer selects instructional events not only by learning outcomes, but also by CAI strategy.

Regardless of the CAI strategy used, the outcome-based performance remains the same for a given learning outcome (i.e., whether it is a simulation or tutorial, example classification is a requisite student performance in the lesson). However, the instructional events vary for the same outcome depending on the strategy ("eliciting the response " differs in a concept game vs. problem solving tool vs inductive tutorial). In some cases, an event may not be present at all (no "present the information" event in a game or problem solving tool). Teachers then learn lesson design best by learning how to: a) identify the outcomes of their lesson (the most crucial step), b) select a CAI strategy for that outcome, and c) utilize the instructional events of that strategy/outcome microstrategy to design the instructional component of the lesson.

3. Every CAI lesson should contain an introductory Readiness for Learning microstrategy that encompasses two events: a) recall of prior knowledge, b) preparation for new knowledge. These elements

are distinct in their definition and their effects on learning. They each can be done by the computer or via off-screen activities. They are at once the two most neglected but important components of a CAI lesson.

4. Effective CAI lessons can utilize off-screen activities as part of their microstrategy events. In many cases, asking the student to consult a book, teacher, or student may be a viable part of the computer lesson (especially for problem-solving outcomes that have practice and evaluation components that are difficult to design for a novice programmer). In particular, research has indicated that diadic and triadic student groupings can facilitate learning and performance in problem solving activities. For example, readiness activities can be conducted by the instructor before students start on a lesson. This CAI design assumption is particularly crucial to CAI designers that are teachers, for two reasons: a) experienced instructors can utilize lesson activities that they know have worked, even if they cannot be programmed into the computer, b) CAI lessons with off-screen activities can be easier to design and code than a similar stand alone lesson that programs all activities into the computer. Once off-screen activities are legitimized as part of the overall CAI process, teachers lose the common and harmful presupposition that CAI instruction must all be in the computer as a stand-alone process; that using media, text, or people is "cheating".

THE INSTRUCTIONAL PROGRAM USED TO TEACH OUR CAI MODEL

First, students receive an overview of why and how instructional design is done for CAI. Following that, the student learns how to:

1. Determine the objectives of a lesson.

↓

2. Conduct a task analysis of the lesson (hierarchy or info processing)

↓

3. Classify the learning outcome(s) of the lesson

↓

4. Design a Readiness for Learning lesson component

   i. assess prior knowledge of the learner
   ii. recall prior knowledge in learner
   iii. describe objectives & content of lesson

↓

5. Design the CAI instructional component:

First, by choosing outcome to be taught (several cycles of this may be completed in one lesson, for multiple outcomes).

Second, by choosing instructional strategy for the given outcome (tutorial, game, etc.).

Third, determining the necessary microstrategy of instructional events, based on text prescriptions and teacher experience.

Fourth, following workbook guidelines to construct lesson component on paper.

↓

6. Convert workbook program design into screen displays.

↓

7. Conduct formative evaluation of lesson via screen displays.

EVIDENCE OF THE MODEL'S SUCCESS
(This will be summarized in the presentation)

Results of approach: no hard empirical data: this is tough to derive when evaluating the effectiveness of a semester-long intervention via use of a course text. However, 15 graduate teacher education students in a Spring '87 class used the approach in designing tutorial software. Their instructional products using a Superpilot system were all at the A or B+ level for a project grade (as graded by the authors of this presenation), with appropriate readiness activities, interactivity, and practice sequences.

The biggest student difficulty in the course was in appropriately identifying the proper learning outcomes (confusion on rules vs. concepts, rules vs. problem solving). However, students tended to embody the basic instructional events for each type of outcome in their lesson, and (as we hoped) transcend these with the addition of their own supplementary design components, indicating that teachers may not have to be taught all design components for each CAI strategy/outcome as much as they need to learn the basic microstrategy instructional events from which to work. Students' course ratings were highest on survey questions about the ease of use of the workbook and its help in achieving course goals. Since students programmed their lessons themselves, we were not able to test the premise that a teacher's screen displays can be coded into the computer by another programmer.

OTHER FEATURES OF OUR APPROACH
(Included in AECT presentation if time permits)

1. *Explanatory feedback should be provided for right answers, which are more than just confirmation of success.* This is because students can guess at right answers, and also make "correct but not perfect" answers that have some mistakes in them (Hazen, 1985). Also, different types of wrong answers receive different types of feedback, depending on the type of wrong answer, and number of tries.

2. *Use of learning strategies as an option for tutorial programs.* In the workbook, teachers are shown how CAI lessons can ask students to generate their own images, mnemonics, or examples for a given learning outcome.

3. *Deemphasis of verbal information CAI lessons.* Teachers are told that verbal information lessons can be more efficiently taught outside of CAI. If verbal information is a prerequisite of intellectual skill of the CAI lesson, it can be taught on the computer.

4. *Reference-text approach.* For the first part of the book, everyone learns the same necessary design activities (task analysis, objectives, outcomes, readiness for learning). For the next part, students can reference individual sections of the book, depending on the outcomes they are trying to teach. In the last section, everyone completes the same section on screen display design. This allows for a learn-as-needed approach to CAI lesson design. With this format, the book can also be used as a reference tool for on-the-job courseware design.

As part of a formal course, teachers can also complete all the workbook exercises in each chapter, to achieve a better understanding all types of CAI instruction. This is explained in a How to Use this

Book section of the workbook, a feature missing from too many instructional texts.

5. *3 Stages of formative evaluation.* The book explains that there are three cycles of formative evaluation that can be conducted for CAI: a) evaluation of the front-end analysis of objectives and task analysis by an SME (a teacher or a designer), b) evaluation of the screen displays by students and/or an SME, c) evaluation of the lesson on the computer.

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Figure 1
Strategy-by-Outcome Matrix for Microstrategies

	Verbal Info	Concepts	Rules	ProblemSolving
Tutorial	MICROSTRATEGY	Definition Proto. Examp. Proto. Nonexp. Examp Classf. Attb. error fdbk.		
Simulation				
Game				
Drill and Practice				
Problem Solving Tools				

Title:

Individualizing Instruction with Microcomputer Produced Text

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Individualizing Instruction with Microcomputer Produced Text

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Background

For much of its history, education in this country has meant "school operations that were uniform in reflecting group norms" (Fantini, 1980, p. 28). Much of the research in education has been directed along the lines of finding the best method for delivering information to a normative group. The assumption was that there was one method that was best for all students. As a result, educational programs were designed for groups of students, such as a particular grade or age level.

In daily practice this required each student to adapt as best as he or she could to the educational method being used. Yet few people would deny that in any group of students there exists a wide range of differences in ability to handle information in a subject area. Those most successful at adapting to the instructional method being used advanced within the educational system, while those less able to make use of what the system offered often withdrew and/or were placed in special tracks.

Educators have long expressed dissatisfaction with this approach. In 1911, Edward L. Thorndike called for breaking away from this uniformity in order to design instruction better suited for the needs of the individual. This thinking was echoed by Carleton Washburne in 1925. In his introduction to the twenty-fourth yearbook of the National Society for the Study of Education entitled "Adapting the Schools to Individual Differences," he wrote:

> Throughout the educational world there has therefore awakened the desire to find some way of adapting schools to the differing individuals who attend them. (p. x)

To date, however, little progress has been made in designing and implementing instruction for the individual. Although educational reformers have introduced a variety of innovations, most of these innovations have not dealt with individual differences of the students. The majority of these approaches have been comparisons between new "Method B" applied to all the students and existing "Method A." As a result new methodologies have seldom shown any real improvement in the educational process.

Individualizing Education

The concept of designing instruction for the individual rather than for a group has received renewed interest in the past two decades. Snow and Salomon (1968) state:

> if the variables used to stratify the group are well chosen, then at least the stage has been set for a new kind of instructional improvement, one based on the hypothesis that there is no "one best way" to teach anything (p. 343).

In 1980 Fantini wrote about the progress to date:

> The age-old fact that no two people are alike, that they have different needs, unique interests, talents, aspirations and problems, and learn in different ways has finally begun to penetrate the mainstream of our schools. Consequently, the school front has become the scene of a revolutionary struggle to alter institutional uniformity geared to group norms toward structures in which the individual uniqueness of the learner is given fuller play...
>
> Attempts to find one method that would reach 100 percent is fruitless... The point is that we are now at a stage theoretically and practically in which we should be able to generate the capacity to tailor programs to fit individuals. No one method can be considered superior to the other except as it contributes to the learning of the individual (p. 28, 30).

Ausubel (1968) defined perception as an awareness of an object or event prior to the cognitive processing of that object or event. Due to the amount of information to which people are exposed, perception must be selective. This selection is based upon their experiences, expectations, goals, values and other influences--in other words, their individual differences. People continually scan the available stimuli and select certain stimuli for processing. Exactly how a person scans a field and to what parts he/she pays attention is greatly influenced by differences within the individual. By looking at how individuals differ on certain variables, it may be possible to make predictions as to what parts of the environment they will process. By relating this information to learning, it then becomes feasible to apply it in the design of instruction.

The Study

The current study attempts to relate an individual difference variable to one aspect of learning. The learning process being used is the ability of the student to read and understand text information presented on a computer screen. The study employs the Trait-Treatment-Interaction or TTI methodology using field dependence-independence as the trait.

This study follows the writings of several authors (Snow and Salomon, 1968; Glaser, 1972; Ingersoll, 1974; Di Vesta, 1975) who have suggested that the emphasis in research on learning should be on the cognitive processes of the individual working with a particular learning performance.

> Both traits and treatments may affect, and in some cases will dictate, whether the receivers will attend, to what they attend, whether they will try to learn by rote or for understanding, whether they will form images or verbal statements, whether they prefer to use the visual over the auditory modality, and so on (Di Vesta, 1975, p. 189).

The TTI methodology was chosen because it allows the manipulation of one or more treatments in conjunction with traits of the participants. The results are intended to show how interactions between one or more of the treatments and one or more traits of the subject affect the outcomes.

Field dependence-independence is used as the trait because it has been the subject of considerable study and a number of the characteristics identified with field dependent or field independent individuals seem to have a relationship to learning. Generally, field dependent individuals are governed to a large extent by the organization of the field. Field independent individuals are characterized by an articulated cognitive style. This type of person analyzes and structures experiences depending upon the task at hand and is not as easily influenced by a structure that is present.

Neither end of the continuum is clearly superior in concept attainment or other aspects of learning. Field dependence-independence is related much more closely to **how** people learn than to **how much** is learned.

A list of field dependent-independent characteristics that relate to learning include:

Field Independents	Field Dependents
1. Impose organization of unstructured field.	1. Take organization of field as given.
2. Sample fully from the nonsalient features of a concept in order to attain the relevant attributes and to form hypotheses.	2. Dominated by the most salient features of a concept in the attainment of the relevant attributes and in hypothesis formation. Can sample fully from set of features if they are in discrete form.
3. Utilize the active approach to learning, the hypothesis testing mode.	3. Utilize the passive approach to learning, the intuitive mode.
4. Learning curve is discontinuous--no significant improvement in learning a new concept until the appropriate hypothesis is found, then sudden improvement.	4. Learning curve is continuous--gradual improvement as relevant cues are sampled.
5. Use mnemonic structures and reorganize materials for more effective storage and retrieval of information.	5. Use existing organization of materials in cognitive processing.
6. Learn to generalize to object and design concepts more readily.	6. Less effective in generalizations from original design to variations on basis of common components.
7. Prefer to learn general principles and acquire them more easily.	7. Prefer to learn specific information and acquire it more easily. (Thompson, 1987)

Fleming and Levie (1978) state that performance on a learning task is more rapid if the salient cues are relevant and less rapid if the salient cues are irrelevant to the learning task. Since field dependents tend to be dominated by salient cues, and ignore nonsalient cues, Goodenough (1976) hypothesized that when the salient cues are relevant, field dependents would learn the material at least as easily as field independents since they (field dependents) pick out the salient cues for processing. He further suggested that field dependents might learn the material more easily under these conditions due to their reliance on salient cues.

Witkin et al., (1977) found that field dependent people, who lack the ability to organize or structure information internally, are aided by materials that provide structure. The more structured the mediator the more that field dependent person's performance was helped.

A previous study using FDI and center and side headings as salient cues in printed instructional text (Thompson, 1987) did show an improvement in the scores for field dependent participants when the cues were present. In addition, field independent participants scored higher when using the text without the headings. This latter finding seems to indicate that the imposed structure interfered with the cognitive processing of the field independent participants.

Based upon this research, it appears plausible that FDI has an influence upon the way in which an individual gains information from his/her learning environment. A problems arises in the fact that the delivery system was printed text. This severely limits the amount of individualizing of instruction a teacher can do, if different versions of handouts must be generated within each group of students.

With the increase of newer technologies in the classroom, a possible solution to this logistical problem has presented itself. Restructuring information for individuals is a relatively simple task when using a microcomputer as the delivery system. Therefore, instructional text as presented on a microcomputer screen has been chosen as the medium for distributing the instructional information. Specifically this study will attempt to determine if the presence or absence of headings aids in the cognitive processing of the material as presented on a microcomputer screen.

Methodology

The participants in the study will be classified on the individual difference variable field dependence-independence using the Group Embedded Figures Test. Then the participants will be divided randomly into two groups: one half will receive a selection of instructional text on a microcomputer containing key words used as center and side heading; the other group will receive the same selection of instructional text minus the center and side headings. After reading the instructional text, both groups will take an objective test over the information.

The sample for the study will be approximately 200 undergraduate college students enrolled in at the University of Wisconsin Stevens Point during 1987-1988. The approximate age range of the students is 18 to 30 years. An undergraduate college population was chosen because the individual difference variables used here are relatively stable at this age (Wolitzky and Wachtel, 1973).

Hypotheses

Based upon the review of the literature the following hypotheses have been developed:

1. There will be a significant difference between field dependent participants and field independent participants on scores of tests over instructional text with center and side headings and without center and side headings.
2. Field independent participants will score significantly higher than field dependent participants on tests over instructional text when the instructional text does not contain center and side headings.
3. Field dependent participants will score at least as well as field independent participants on tests over instructional text when the instructional text does contain center and side headings.

Statistical Analysis

The design of this study involves the use of two independent variables--field dependence-independence, and the presence/absence of center and side headings in the instructional text, and one dependent variable--the score on a written test over the reading material. For these reasons the statistics chosen will be a two-way analysis of variance.

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Title:

The Theoretical Foundations of Educational Technology and Future Directions for the Field

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The Theoretical Foundations of Educational Technology and Future Directions for the Field.

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Introduction.

A major criticism of the field of Educational Technology has been that it has tried to be all things to all people. Referring to definitions of the field (Ely, 1972; Silber, 1970; Rowntree, 1974; AECT, 1977), Nunan (1983) points out that Educational Technology appears to claim a role in all aspects of Education, differing only from the other subfields by being more systematic in what it does. This, added to the tendency to equate the practical application of knowledge -- our stock in trade -- with a rejection of theory, has led to a situation where the field is being pulled in many directions at once and lacks an anchor point to give it stability. It is therefore necessary to identify what the theoretical foundations of the field are and to propose how the field can build itself up from a solid foundation in theory. The recent book by Gagne (1987) takes an important step in this direction in that its chapters concentrate for the most part on learning and instruction. This paper attempts to go further in this direction and to strip the field down to its essentials.

The purpose of this paper is not to suggest another definition for the field. Rather it seeks to examine an extant one in such a way as to make the field's foundations clearer. The definition is not new to Educational Technologists. It is based on Galbraith's (1967) definition of technology as "the systematic application of scientific and other organized knowledge to practical tasks." If we substitute "educational tasks" for "tasks" and "knowledge about Education" for "knowledge", then we have a definition of the field that has been accepted by those working in it for years.

It is important that this definition implies that Educational Technology is a process. What is more, it is a decision-making process that Simon (1981) and Glaser (1976, 1985) have called "design". It is certainly not a theory, as AECT (1977) has claimed if for no other reason than the fact that processes, while guided by theory and in some cases even producing theory, cannot themselves be theory. (Whether Educational Technology is a discipline and a field, which AECT also claimed, is debatable but beyond the scope of this discussion.)

The definition points to how theory might relate to Educational Technology. Indeed, theory has the potential for fitting into each of the three parts of the definition. "Systematic application" is not itself theory and instructional development is atheoretical. Yet it is conceivable that a theory might be developed that explains and predicts how following different development procedures could lead to different learning outcomes. Gerlach (1984), for one, has stated that research that might lead to such a theory is urgently needed. "Practical educational tasks" are not theory either. Yet some aspects of curriculum theory, aligned closely with Sociology and Political Science, do explain and predict how the practical tasks of Education are identified in particular social and political systems. Yet in neither of these cases does theory exist that Educational Technology can point to as its own.

It is in the "scientific and other organized knowledge about Education" that the theory that drives Educational Technology is to be found. The examination of the definition of the field, which is the purpose of this paper, must therefore begin with a clarification of what the theory that contains this knowledge is, for it is here that the foundations of the field must lie. As we shall see, once the theoretical foundation of the field has been acknowledged, it will be necessary to rethink certain aspects of how that knowledge is applied, and even the scope and nature of the practical tasks that Educational Technology is best fitted to address. What will result is a narrower conception of the field, but one that is more manageable, more viable, more respectable and more unique.

Theoretical Foundation.

It is the contention of this paper that the main theoretical foundation for the field is cognitive learning theory. In order to support this contention, convincing arguments must be presented: that psychological theory is more central to Educational Technology than, say, system theory or theories of management; that cognitive theories are more useful than behavioral theories; and that theories of learning are more fundamental than theories of instruction. The case for each of these is progressively harder to make. But it can be made as we shall see in the following sections.

The need for Psychological theory.

The "bottom line" of Education is learning, and learning is a psychological process. This is so obvious that it seems that there is nothing more to say. Yet there are those who argue that this is not the case, and that theories of management, or system theory, are really what Educational Technology should be founded on (see Heinich, 1984). Doubtless such theories are important and relevant. But they are not fundamental. For example, a major purpose of management theories, applied to education, is to make educational institutions more efficient, which is fine and necessary. But the need for efficiency in educational institutions is determined in turn by the need to help students learn. Regardless of how far from students one's concerns for institutional efficiency are, the students are always there, and the results of any action one takes can always be traced when all is said and done to a student somewhere attempting to learn something.

A similar argument can be made for system theory. This mathematical theory of the behavior of complex organisms (Bertalanffy, 1968) has been thoroughly misunderstood, misinterpreted and abused by a great many educational technologists. It is concerned with how complexity might be described and controlled, and permits us to consider systems as wholes. It is only secondarily concerned with systematicity in decision-making, or design. And even then, we have grossly oversimplified the basic theory. In fact, the majority of the embodiments of "the Systems Approach" have nothing to do with system theory at all and are nothing more than rather fatuous and unsuccessful attempts on the part of some instructional developers to make their work appear to be theoretically rigorous (which it is not). Davies (1981), Andrews and Goodson (1980) and others have, to their credit, clearly spelled out the difference between being systemic and being systematic. With the emphasis on being systematic rather than systemic, instructional design and development "models" often appear as no more than lists of steps which, if performed in the correct order, might, with luck, lead to instruction that is reasonably effective. Such a conception of decision-making is so utterly devoid of theory that to call it an application of system theory is quite ridiculous.

The exception proves the rule, of course. In those cases where educators have understood system theory, it has proven to be the powerful tool that it has always had the potential of being. I will give three examples. The first is the work of Heinich (1970, 1984) who has been very successful in drawing to our attention the great complexity of educational and instructional systems and how the introduction of technology into the educational milieu makes these systems even more complex. Yet Heinich's application of system theory to education is for the purpose of educational and instructional management, which is to say it is at least one step removed from the student who is trying to learn something. The "paradigm" for instructional management presented in the 1970 monograph describes various ways in which technology and teachers might fit together in workable ways in order to instruct. But, wisely, it does not say anything about the nature of the instruction that might be designed and delivered. (I might add that the chapter on learning theory is the least successful in this important book).

The second example is to be found in the admittedly difficult writings of Pask (1975, 1984). Pask's "Conversation Theory" is something of an offshoot of system theory in that it is largely concerned with mechanisms of feedback and other cybernetic constructs that are relevant to the interaction of an organism with its environment. Pasks' theory is nonetheless concerned with education and provides an ample framework within which to explain how the learner, as a system, assimilates new knowledge and accomodates to it.

The third example is, perhaps suprisingly, the work of Piaget (1967). While Piaget is not primarily thought of as a systems theorist, there are nonetheless many echos of system theory in his work. (Like Von Bertalanffy, he was a biologist by training, and they certainly knew each other). The notions of assimilation and accomodation, which are fundamental to Piagetian theory, are more than coincidentally similar to catabolic and anabolic processes in living organisms, explained by system theory. Equilibrium and homeostasis are to all intents and purposes identical constructs.

And Piaget's (1970) book Structuralism, little read by educators, likewise contains many ideas that are traceable to system theory.

Something quite fascinating appears when you consider these examples. First, as we have seen, Heinich does not apply system theory directly to instructional decision-making. We therefore cannot consider it to be fundamental. Second, in the work of Pask and Piaget, the application of system theory to education takes place in a psychological context. Pask and Piaget are not concerned with being systematic while doing instructional design, nor even with instructional strategies and methods, but with the psychological implications of looking at the learner as a complex cognitive "organism". Thus, we might easily conclude that when system theory is properly applied to education, it is either only indirectly concerned with instruction (as with instructional management, for example), or else it is concerned with psychological issues. Only in the latter case is it directly concerned with the learner.

The need for a cognitive emphasis.

Doubtless, those psychological theories that have been most successful in guiding instructional design have been behavioral. The work of Skinner (1954), for example, produced a descriptive theory of learning called "operant conditioning", a prescriptive theory of instruction derived directly from operant conditioning, techniques for delivering instruction such as teaching machines and programmed instruction, and even a philosophical frame of reference (Skinner, 1971) which stressed the necessity for man to give up freedom and dignity in order to survive. The whole forms a package whose completeness has not subsequently been matched. Likewise, Gropper's (1983) behaviorally-based instructional theory is the most thorough of all of those presented in Reigeluth's (1983) compendium.

However complete, thorough and practical behavioral theories of learning and instruction might be, they are nonetheless based on an inadequate account of how people learn. (As we shall see, the choice we have to make in our field is whether we do what we do well but limit our effectiveness to only a few aspects of instruction, or whether we try to broaden the applicability of what we do at the risk of doing it less well for the moment. Obviously, I have opted for the latter). The arguments for a cognitive approach to learning and instruction are many, convincing and largely known. They range from Koestler's (1967) contention that there are emergent properties of human thinking that behaviorism cannot explain, to Neisser's (1976) account of the importance of schemata in determining what is learned, to Wittrock's (1979) description of learning as a generative process. Shuell (1986) has provided a thorough account of the major components of cognitive learning theories.

Our field remains wedded to its behavioral roots. There are two reasons for this. First, historically, the field found its feet during the heyday of Behaviorism in the early 'fifties, when programmed instruction was "all the rage". Had the field grown up in the 'twenties and 'thirties, alongside Gestalt psychology, for example, it might have looked very different today. Second, instructional design as we have come to know it can only flourish within a behavioral context. This is because any instruction whose design is separated in time from its implementation can only ever present information as stimuli for students to react to. Students cannot modify the program of instruction (the stimuli) to any extent without it falling to pieces. This is why instruction produced through the usual design process is most successful in those situations where students are largely passive and are learning lower-level skills (in the Gagnean sense), that is to say in training settings.

When one acknowledges that students are capable of thinking for themselves, and that learning occurs when someone acts upon information rather than simply reacting to it, two things become clear. The first is that instruction has to be sufficiently flexible to deal with all of the things that happen when cognitively active learners engage in it and that could not have been anticipated by instructional designers. This requires that some, even if not all of the instructional decisions must be made in interaction with students once instruction has begun. This is normally taken care of when a good teacher delivers the instruction (Nunan, 1983). The second thing that becomes clear is that most current "models" of instructional design are largely inappropriate in a cognitive context. This is because they require that all instructional decisions be made, and tested, before instruction is implemented, and that they leave no room for adaptation once instruction has begun. There are, of course, exceptions. The work of Greeno (1980), Resnick (1976) and others has given rise to a variety of cognitive instructional design procedures. But once again, these have emerged directly from psychological theory and research and not from educational technology.

It is, therefore, only when instructional decision-making occurs during instruction, either through the agency of a good teacher or of an intelligent tutoring system, that it is possible for instruction to follow the principles of cognitive theories of learning and instruction. This implies a new role for instructional designers (Winn, 1987). Rather than selecting instructional methods given what the outcomes of instruction are to be and the conditions under which it is to occur, designers will increasingly be concerned with studying how such decisions are made and with building instructional systems that are capable of making them.

Theories of learning and of instruction.

The final stage of our argument requires us to look at descriptive theories of learning and prescriptive theories of instruction. As Reigeluth (1983) has pointed out, learning theories are not necessarily descriptive, nor are instructional theories necessarily prescriptive. But for our purpose, it is sufficient to distinguish between descriptive theories that describe what happens when someone learns something and prescriptive theories that tell us what to do in order to get someone to learn something. The argument is that descriptive theories are more fundamental to educational technology than prescriptive theories in contrast to what is currently believed to be the case.

The first point to make is that descriptive theory precedes prescriptive theory. While this does not imply that descriptive theories can necessarily be simply restated in prescriptive form, as Landa (1983) has pointed out, it does suggest that we have to be able to describe something before we can determine what it is that we have to do in order to bring that something about. Behavioral theories of learning and instruction are perfect examples of this. The work of Pavlov, Skinner and the other behaviorists was originally descriptive. It described and explained what happened when a stimulus was presented to an organism under various conditions. Prescriptive theory was only possible once this explanatory theory had been well developed.

The second point is that one of the reasons behavioral theories of instruction are, within their limitations, so complete is that they are built from what is known about the conditions that are necessary for learning to take place. As Clark (1983), among others, has pointed out, theories of instruction fall short of satisfactory if they merely address the sufficient, as opposed to the necessary conditions of learning. Thus, while we can demonstrate that giving a rat an electric shock may be sufficient to extinguish a learned behavior, so may a whole host of other negative reinforcers. The key to this form of extinction is therefore not the realization that an electric shock extinguishes learning but the more general theoretical principle of negative reinforcement. This is relatively clear in the case of behavioral theories as these are well developed and complete.

The same cannot be said for cognitive theories. Because they have to account for far more complex phenomena than behavioral theories, and because research aimed at developing them began more recently than behavioral research, they are far less developed and complete. This has had two results. The first is that prescriptive cognitive theories of instruction, such as they are, are incomplete and therefore less reliable than they will be. Second, instructional designers have been tempted to derive principles from the bits and pieces of cognitive research that have been completed, and have therefore relied, often unwittingly, on what is known about the sufficient, rather than necessary conditions of learning. This not to say that there is no descriptive cognitive learning theory. The work of Neisser (1976), of Rumelhart and Norman (1981) and many others belies that assumption. The problem stems from the less complete state of cognitive theory and from the fact that instructional designers by and large do not know the difference between sufficient and necessary conditions. The prescriptions for action in cognitive theory simply do not exist in sufficiently reliable form for them to be useable.

What this means is that descriptive theories of learning are, at present, more reliable than prescriptive theories of instruction within the cognitive framework. It is therefore best if instructional designers work with descriptive theory rather than with incomplete and sometimes misleading prescriptive principles. With a knowledge of how people learn, the designer can act as each set of circumstances permits and at the same time adapt theory to particular needs rather than blindly following "cookbook" prescriptions for instructional design.

Theory-based instructional design.

Stewart (1985) has criticized the instruction students in educational technology programs receive for teaching techniques rather than principles. Clark (1978) has, likewise, levelled criticisms at our graduate programs from not emphasizing research and inquiry. Both of these criticisms are justified. If students are taught that instructional design is a simple process that leads to effective instruction provided that the instructions in each box in a flowchart are carried out and that the selection of instructional strategies can be achieved by looking them up in a table, then they have been taught techniques that are not founded in theory. The instructional designer trained in this manner can "do" instructional design up to a point, provided that nothing unforeseen occurs. But that designer cannot reason about what he or she is doing and therefore has great difficulty transferring the design skills learned in the design course to any "real-world" setting. The designer trained in this way is at a particular disadvantage when a problem shows itself during the field testing of instruction whose solution has not been directly addressed in the design course.

When one looks at the way in which an expert in any field functions, one finds that they do not simply use techniques for getting the job done. Schon (1983, 1987) has characterized professional expertise by the ability to carry out what he calls "reflection in action". Reflection in action is nothing more nor less than the ability to reason about problems from first principles, to conduct, if you will, small spontaneous experiments that are guided by a general theoretical framework but aimed at particular and usually unforeseen problems. Schon documents his two books with examples from a number of professions. In each case, we see expert professionals achieving an impressive blending of theory with practice through what is in effect spontaneous research. If Educational Technology is indeed a profession, this is a standard that it should emulate.

What might instructional design look like given Schon's conception of things? To begin with, the emphasis in design training would be less on techniques and more on the acquisition of a well-founded knowledge base. It would also be accompanied by an extensive "reflective practicum" in which the student would be apprenticed to an expert designer who in addition to being good at design would also be good at helping the student reflect in action. In other words, the designer would have the ability to make students reason from first principles rather than simply helping them find which techniques to apply.

Once beyond training, the instructional designer would refer to knowledge about how people learn in order to draw guidance in instructional decision-making. The advantage of this would be that variations in the context in which instruction is to be designed would cease to be problematic. The designer would be able to function at a level of generality sufficient to transcend the specific nature of each instructional setting. Theory, remember, is by definition sufficiently general and robust to be valid in all situations. It has the property of being able to predict what will occur even if the circumstances are entirely new.

A final comment. It is quite likely that before long computer-based expert systems will be doing instructional design (Merrill, 1987). But it will be a long time before computers can reflect in action. This means that computer-based instructional design systems will operate at the "technique" level and will design instruction that continues to be behaviorally oriented, predetermined and incapable of all but the crudest of adaptations to changing conditions during its implementation. Instructional designers will still be needed to bring their knowledge of learning theory to instructional problems and to reason from first principles, which is something that computers will not be able to do for a long time.

Conclusion

We have argued that the foundation of the field of Educational Technology is to be found in cognitive theories of learning and we have seen how this might change the way in which instructional designers ply their trade. By way of conclusion we shall look at an important implication of this for the practice of the field.

Doubtless the ideas presented so far will not go down well with those in our field with a more "practical" bent. The history of our Association reveals that there has always been opposition within the field to research and theory that has at times bordered on hostility. This is to be expected. Educational practitioners are handicapped by all manner of constraints that make it difficult for them to operate from first principles. They have little time for decision-making themselves and there are few incentives for them to be innovative. They have in all likelihood been trained in the first place in a program that emphasizes techniques rather than theory and principles. And their orientation is probably behavioral. They are therefore probably not only unwilling but also unable to reflect in action in order to make instructional decisions.

If for no other reasons than these, it can be concluded that if Educational Technology is to survive, develop and thrive, then it must do so outside the traditional structures and institutions of Education. This is an argument that Heinich (1984) has made already, and the reader is referred to his insightful and prevocative article. It is worth noting that, in the estimation of many, some of the most successful applications of Educational Technology have indeed occurred outside these traditional structures. (Britain's Open University comes immediately to mind). It is also worthy of note that these successes have occurred without heavy reliance on the "techniques" of instructional design that are taught in most of our graduate programs.

The other side of the coin is that traditional institutions are doing just fine and have no need for Educational Technology (Nunan, 1983). This should not be taken as a condemnation of the field but as further evidence that it is more likely to succeed elsewhere. Training and any situation where the student interacts directly with instruction without the mediation of a teacher are examples of situations in which instructional design has an important role to play.

We began with the idea that the field and the Association are trying to go in all directions at once and are, as a consequence, not going anywhere at all. It is hoped that the arguments put forward above will at least be considered by Educational Technologists and that, founded on cognitive theories of learning, the field can advance to the status of a true profession whose members eschew techniques in favor of reasoning from first principles. If the mastery of this approach to the discipline can be demonstrated, it is quite likely that we will be invited to contribute in a major fashion to the reforms of American education that are bound to occur within the next few years.

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Title:

Attitudes, Learning and Human-Computer Interaction: An Application of the Fishbein and Ajzen Model of Attitude-Behavior Consistency

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Attitudes, Learning and Human–Computer Interaction: An Application of the Fishbein and Ajzen Model of Attitude–Behavior Consistency

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A paper presented to the Research and Theory Division of the Association for Educational Communications and Technology, New Orleans, Louisiana. January, 1988.

Attitudes, Learning and Human–Computer Interaction: An Application of the Fishbein and Ajzen Model of Attitude–Behavior Consistency

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The Fishbein and Ajzen model of attitude-behavior consistency was applied to 56 undergraduates learning to use a microcomputer. Two levels of context for this act were compared: the students' beliefs about themselves and their beliefs about people in general. The results indicated that students' beliefs were good predictors of their behavioral intentions and they thought that learning to use a microcomputer would be significantly more helpful to them than to other people. The findings are congruent with the Fishbein and Ajzen model of attitude-behavior consistency. Examining attitudinal and normative beliefs about specific behaviors provides useful information on learning and technology.

Introduction

Research on human-computer interaction (HCI) has emphasized ease of use but understanding successful interaction means discovering what human characteristics are involved in learning to use (National Research Council, 1983, p. 114). Educational researchers investigating the issue of learner attitudes towards microcomputers have tended to concentrate on computer anxiety, a single dimension of a multidimensional attitude, and their instruments range from semantic differential scales (Williams, Coulombe & Lievrow, 1983) to self-constructed Likert scales (Maurer & Simonson, 1984). This one dimension of affect must be distrusted (Cambre & Cook, 1985; Howard & Smith, 1986). Beyond intuitive opinions of computer anxiety, such as those presented by Schneiderman (1986, p. 426), there needs to be better understanding of learner attitudes so that assumptions on the part of instructors do not prejudice the opportunities of students to learn. Fishbein and Ajzen's model of attitude-behavior consistency (Fishbein & Ajzen, 1975; Ajzen & Fishbein, 1980) can contribute to better understanding of attitudes and be more meaningful towards predicting behavior (Travers, 1982, p. 393). In conducting the investigation reported here a philosophical stance was invoked from the Fishbein and Ajzen theory of reasoned action: learning, as a behavior, is to some degree volitional and guided by the behavioral intent of the individual.

Background

Fishbein uses attitude to refer to "a learned predisposition to respond to any object in a consistently favorable or unfavorable way" (1967, p. 477). Evaluative beliefs about an object and the strength of those beliefs function together as the basis for predicting an individual's attitude and is expressed by this algebraic figure (Fishbein & Ajzen, 1975):

$$B \sim BI = [\sum_{i=1}^{n} B_i E_i] W_1 + [\sum_{i=1}^{m} N B_i M C_i] W_2$$

The first half of the equation describes the attitude towards the behavior in question. Overt behavior (B) and the intent to perform that behavior (BI) are a function of beliefs (B_i) about that behavior leading to consequences. The evaluation of those consequences is E_i and indicates the strength of those beliefs.

The logic of the second part of the formula runs parallel. It describes the influence of other people on the actor's normative beliefs and how much the actor is likely to accede to them in general. The normative belief, as perceived expectation of referent i (NB_i), is multiplied by the motivation to comply with referent i (MC_i). The two components of the formula are empirically weighted relative to intentions by regression (W_1 and W_2).

Hypotheses

The purpose of this study was to discover the relationships of beliefs to behavioral intent for people learning to use microcomputers. It was hypothesized that the beliefs of learners would correlate significantly with their behavioral intentions. This would test the Fishbein and Ajzen model of attitude-behavior consistency in the context of learning. The particular act, learning to use a microcomputer, is an area of recent research interest in education (Salomon & Gardner, 1986).

As a further test of the applicability of the model two levels of instructional context were investigated, specific and the global. The model could be refined relevant to learning by demonstrating that generality in context elements decreases the predictive validity of attitude measurement towards a specific target. A second hypothesis was generated and students were asked to report not only their beliefs about their learning to use a microcomputer but also their beliefs about people in general learning to use a microcomputer. It was hypothesized that the beliefs of learners about other people learning to use microcomputers would be significantly weaker than their beliefs about themselves learning to use microcomputers.

Method

Sample

Respondents were 56 undergraduates attending a state university campus.

Measurement and Procedures

The contents of the predictive components of the questionnaire were based on expert knowledge of the population and fitted the categories of the Fishbein and Ajzen model. Students had been observed and interviewed the previous semester for two ergonomic studies (Yeaman, 1985, 1986). Computer anxiety did not emerge as a salient belief for this population.

The students were asked to rate attitude statements on seven-point adjective bipolar scales. The questionnaires were given on the first day of the semester as the initial class activity and took five to seven minutes to complete. Prior to data analysis these bipolar scales were scored from plus three to minus three.

Results

Correlations above .8 indicated the data on the attitudes towards the act of learning to use a microcomputer were reliable and consistent. A lack of significant correspondence between the normative aspect and the behavioral intentions was anomalous but Fishbein and Ajzen's model of attitude-behavior consistency, as the theoretical base of this study, does not allow the influence of any component, though nonsignificant, to be discounted (Fishbein & Ajzen, 1976). The equation was computed for each level of context. The students' beliefs about themselves significantly correlated with the sum of behavioral intentions, $p<.001$. The students beliefs about other people also significantly correlated with the sum of behavioral intentions, $p<.01$. These results provided further support for the first hypothesis that the beliefs of learners would correlate significantly with their behavioral intentions.

To test the second hypothesis a comparison was made between the student beliefs about their own behavior and their beliefs about other people's behavior. A t test showed the personal beliefs were significantly higher ($M = 7.49$) than the people in general beliefs ($M = 6.86$), $t(54) = -2.11$, $p<.05$. This supported the second hypothesis, that the beliefs of learners about other people learning to use microcomputers are significantly weaker than their beliefs about themselves learning to use microcomputers.

Discussion

Student beliefs and behavioral intent

The students' beliefs were good predictors of their intent to behave, showing the Fishbein and Ajzen model worked well and supporting the first hypothesis. Scrutiny of the raw data indicated that, contrary to expectations, normative items were not always scored on the positive side of the scale. A negative normative relationship between wanting to comply and behavioral intention was also found by Walster (1986). The convergence between this investigation and Walster's suggests the influences of norms on learners and their motivation to comply with them could be an important area of investigation for research on learning and HCI.

The specificity of student beliefs

The students believed that learning to use a microcomputer would be significantly more helpful to them than to people in general. This particular finding augments the Fishbein and Ajzen model of attitude-behavior consistency by demonstrating that the predictive validity of attitude measurement towards a specific target is decreased by generality in instructional context.

Conclusion

The relationship of learners' attitudes to their learning behavior is often mistaken as a common sense issue and further empirical investigations are recommended. Evidence from theory-based research can provide better understanding. Examining attitudinal and normative beliefs, as related to specific behaviors, shows efficacy relative to the instructional aspects of HCI.

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Title:

The Development of a Research Agenda and Generic Disc for Computer-Based Interactive Video

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The Development of a Research Agenda and Generic Disc for Computer-Based Interactive Video

by

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Presented at the 1988 Association of Educational Communications and Technology Conference, New Orleans, Louisiana

This work has been partially supported by a Syracuse University Senate Research Grant.

Introduction

The purpose of this paper is to describe the development of a conceptual framework for conducting research using computer based interactive video (CBIV) and a generic disc as research tools. In 1977, Schramm advocated that "learning from the media...is an extremely complex multivariate process that challenges us, if we are to understand it, not to ask the simple questions, but rather to concern ourselves with the conditions for selecting one medium over another, for combining and for using media" (in Johnston, 1987, p. 3.). With the technological advances which converted interactive video to computer driven interactive video, it became obvious in the early eighties that designing instruction for this medium was much more complex since more variables could be called upon and combined to create a learning task. What became important, then, was the identification of, and theory-driven specification for, using those multivariate factors available within this more complex and powerful medium.

The Original Research Agenda

After analyzing the components of eight models presenting wholistic conceptions of student learning in classroom settings that were summarized by Hartel, Walberg, and Weinstein (1983), Glaser's model was selected. Glaser (1976) suggests that the design of instruction must account for the following four components:

- knowledge and skills required for performance,
- initial state of the learner,
- conditions to change the learner from an initial state to a state of competence, and
- short and long term outcomes of instruction.

Siegel and Siegel (1964) suggest that a framework serves as an instructional gestalt whose "special virtue is derived from the fact that the framework calls attention to, rather than ignores or minimizes the importance of, the complex nature of the educational process. It focuses research interest upon variables of interaction rather than upon the main effects" (p. 39). Following this suggestion, Grabowski and Whitney (1984) reconfigured the four components suggested by Glaser into a 3 dimensional matrix to function as the overall unifying conceptual framework to study learning with this medium. The three interacting dimensions consisted of the learner (aptitude, prior experiences, motivation, cognitive style, cognitive schema)/content (the content area and the level and type of objectives to be achieved)/instructional process (instructional, sequencing, and presentational strategies) with their interactions affecting long and short term outcome. Overlying this matrix were media attribute choices (modalities, layout, flow, color, timing, volume, realism) available with the computer based interactive video medium which could then be selected for a specific type of learner, for a specific content area and outcome, using a specific strategy. Their goal was to use the framework to summarize current research results and identify gaps in that research with the final intent of developing prescriptions which link theory to the practice of selecting media attributes for CBIV.

At the same time, however, Clark (1983) joined other researchers to caution even more emphatically against conducting, or even advocating, more inappropriate media comparison research. His cautionary advice was also levied against this proposed framework. The intent of the conceptual framework, however, was NOT to focus on media, but rather on media attributes or the forms of instruction. Resolving whether this framework fell under inappropriate media research became extremely important before further work on the model was conducted. The resolution of this problem lies in exploring whether CBIV is, indeed, a unique delivery system and clarifying what type of variables do impact upon "instructional effectiveness."

The Appropriateness of CBIV Research

Viewing CBIV (unlike interactive video which lacks computer control) as one discrete medium is somewhat problematic. In some respects, even the term "CBIV" is inappropriate itself since it defines the technology in terms of only two media -- video and computer. CBIV is, in fact, an amalgam of many media connected and controlled by a computer, and thus, represents the beginnings of a truly "computer based" learning system (CBLS) which will continue to evolve for many years to come. Advances in communication technology have already begun to blur the distinctions between a number of delivery systems such as videotext, computer based learning and interactive video. Viewing CBIV within the larger context of a computer-based learning system is more realistic. Such a multifaceted, flexible and unique delivery system can have important implications for instructional research and instructional development.

First, a CBLS will allow the learner to direct the interaction with the instruction to a much greater extent and perhaps even to the point where the learner will generate his/her own goals and objectives. As Salomon (1986) suggests this technology will allow instruction to become increasingly self-guided, open-ended, and interactive. Therefore, learner variables such as attitude, previous knowledge, learning style will become increasingly important for instructional researchers to investigate. Second, a CBLS system will conceivably allow instruction to take any form imaginable. Questions related to what delivery mode to use and how messages should be represented on a particular delivery mode suddenly become very important. Unfortunately, instructional design models afford the instructional developer relatively little guidance with regard to questions posed by learner characteristics or message design.

This argument leads into the the second issue which involves the clarification of the types of variables that impact upon "instructional effectiveness." The contention (Clark, 1983) that instructional design -- the selection of theory-based strategies that are intended to solve a particular instructional problem -- is the most important activity in the development process needs to be examined more fully. Typically, instructional developers never work from designs that stipulate all aspects of a finished instructional product. In fact, instructional designs are typically lists of strategy components that are deemed appropriate given a particular learning context (Reigeluth, 1983). For example, a design for a lesson that teaches students to classify animals as mammals might include a generality, a series of matched examples and non-examples, a sequence of examples that progresses from simple to complex, practice in classifying, and learner feedback. Reigeluth (1983) refers to such design documents as "blueprints" and describes the role of the instructional designer as akin to that of an architect.

The blueprint/architect is a bit misleading as it suggests a greater degree of fidelity between plan and finished product than actually exists. An obvious question emerges: what remains to be stipulated in addition to the strategy components listed in an instructional blueprint? If we follow the blueprint analogy (such as a blueprint of a house) a bit further, it is readily apparent that a great deal remains to be specified. The house plan is incomplete in a number of ways. The plan does not specify how the rooms should be finished -- what color, shade and texture of floor, wall and ceiling coverings to use. The plan does not specify what furniture to buy and where it should be placed. In short, our house plan merely lays out a shell. Other specifications need to be made in order to make the shell a useful and enjoyable place to live. In instructional terms, an instructional design does not even result in something as complete as the empty shell of a finished house. The major structural components of the lesson are in place but the components need much embellishment in order to yield an instructional product that will be effective and enjoyable for the learner. In essence, the blueprint prescribes the structure of the lesson but it does not prescribe the "form" the lesson should take.

The instructional designer faces a myriad of questions related to the form of the finished instructional product. Instead of plaster and bricks, the instructional designer molds and crafts information into meaningful, effective and pleasing messages -- messages that contain both instructional content and instructional strategies. It is during this process of message design that life is breathed into instructional content and strategies so that a useful product results. The developer must not only decide what attributes to select but how the attributes are to be used. The instructional developer's job is further complicated when working with CBLS. One's choices are nearly unlimited. Errors at this stage -- such as poor screen layout -- result in a muddled, confusing and unappealing product and instructional design models offer very little guidance.

What is interesting about this discussion is that if the media attributes guidelines are stripped away, what remains is a two dimensional matrix of learner characteristics and content with the prescriptions being instructional strategies. This approach ignores the important prescriptive research of Chu and Schramm (1968), Fleming and Levie (1978), Winn (1987), Dwyer (1978), and Jonassen (1982) to name only a few. Research questions regarding form are vital to ask because of their perceived impact upon the "effectiveness" of instruction just as the form of a house will impact on quality of life. The questions regarding content and instructional strategies are important and necessary, but not sufficient as Kozma (1987) states in a recent discussion of this issue. Given that questions regarding the form of the message for various learner characteristics are legitimate to ask and that their answers would contribute to more "effective" instruction as this paper argues, guidelines are necessary, and research is needed to help formulate and validate them. The conceptual framework for CBLS and the CBLS itself are powerful tools for accomplishing just that.

The important and unique aspects of CBLS which make it a powerful tool for formulating those guidelines and conducting this research are important to highlight. The CBLS technology offers a means for carefully studying many instructional and media attributes acting in unison, and the means to "control for" the effects of specific attributes. The implications for research are numerous. For example, a CBLS unit could act as "both stimulus material and data collection device" (Chen, 1986, p. 27). In addition, the research control afforded by CBLS would reduce the likelihood of introducing confounding variables and would ease replication in various settings.

Therefore, the CBLS described here is indeed something new, cannot be described as one distinct medium to be compared with others, and the form available/unique to it warrants further study. The technology's ability to "abolish previous media distinctions" (Chen, 1986, p. 27) and to afford a high level of interactivity is unique. At the same time, the nature of a CBLS will force and enable researchers to examine issues related to learner characteristics and message form more closely and within a more controlled environment.

The Revised Agenda

Given, then, that CBLS message design research is appropriate as described, an altered version of the 1984 Grabowski and Whitney conceptual framework was developed to guide our latest thinking regarding the interaction of accountable components of instruction. This new framework includes learner characteristics, content type, message design, and instructional strategies as the important variables which affect affective and cognitive outcomes. (See Figure 1). As can be noted, learner, content, and instructional process variables are still reflected in this framework, however, the use of a branched flowchart rather than a matrix and the inclusion of message design as a discrete step rather than being overlaid onto the entire model mark the differences. This strategy more clearly reflects the decision process of instructional developers and will also facilitate the creation of an expert system to manage the subsequent development prescriptions, i.e. given a specific content type and instructional strategy, and most important learner characteristics which must be taken into account, message design principles would be selected.

Insert Figure One here.

As described earlier, instructional design models currently offer much guidance to designers for selecting instructional strategies for specific content and outcomes and are well researched. These two components are included in the framework because they are necessary elements, but will not be included specifically in this round of research questions. Therefore, content type and instructional strategy will be givens in the model and will not be varied. Learner characteristics continues to be the key component and remains at the core of the model with the other key feature being message design variables. The purpose of the research agenda is to identify those learner characteristics for which message design can have a major impact. Variations in learner characteristics will be matched and varied with message forms to determine which of the many learner characteristics should be taken into account when developing an instructional message.

Using this structure, a select list of learner characteristics and message design were chosen for their potential for exploring the unique aspects of the computer based learning system. Three categories are included under learner characteristics:

- o the structure of memory,
- o cognitive style, and
- o modality preferences,

Under each of these broad categories of learner characteristics, specific characteristics of special interest were selected:

- o characteristics of the structure of memory
    - -cognitive engagement
    - -cognitive schema matching

- o cognitive style variables
    - -field dependence/independence
        - -organization of information
            - -(serialistic/wholistic,
            - - detailed/global)
        - -social/human aspects

- o modality strength of learning.
    - -message representation
        - -(static visual, auditory,
        - - dynamic, manipulative visuals)

Careful reflection of the special representational strengths of the CBL medium prompted the selection of 5 important variables:

- o interactivity,
- o easily accessed massive text and visual data bases,
- o graphic overlay,
- o video windows, and
- o alternate visual and audio forms.

Five areas of inquiry evolved from interrelating these learner characteristics and message design variables of the CBLS, and will be described next.

Interactivity and cognitive engagement. The interactive nature of the CBLS is a naturally powerful medium for cognitive engagement. Cognitive engagement entails much more that merely controlling pace and sequence. It assumes an active involvement of all stages of the memory, with special emphasis on the working memory. Through the working memory, students relate stimuli from the environment to information in long term memory, and are mentally active during this process. Simply controlling the pace of a lesson (press return to continue) or the sequence does not activate that extremely important activity of interacting with the material. While Hannafin et.al. (1985, 1986), Gay (1986), Carrier, (1985) and others are actively researching various aspects of learner control, this agenda will seek to explore the "transactional" (Merrill, 1985) effects of "dialoguing" with the system. The additional representational capabilities of the system extend the research from dialogue with computer generated text and animation to a dialogue with full audio and video fidelity from the videodisc. This leads to the following research question:

- What effect will cognitive engagement through instructional transactions with the full audio and video fidelity have on learning?

Text and visual data bases and cognitive schema. The main strength of the CBLS is its extensive storage capacity of both high fidelity audio and video, and computer data. The power of the system, however, lies in its computing capacity to manipulate the extensive stored data. These characteristics make it more feasible to research cognitive schema matching than it ever was before. Tapping in on the higher level information processing capabilities of the learner through assimilation and accommodation should result in a deeper understanding of the instruction. By first identifying the learner's organizational representation of the content in his/her own mind, two strategies can be explored. The first is to tie the new information to the existing patterns of thought in the learner. The second is to try to alter the patterns of thought to that of the "expert." In either case, visual or textual display can be manipulated by information from the original schema of the learner. Research questions specific to this topic include:

- What effect will matching existing cognitive schema with visual and textual data base information (reflecting either the expert or novice organization of information in the lesson) have on deep processing?

Graphic overlay and field dependence/independence. With graphic overlay capability, highly dense visual information can be simplified, and very simple displays can be enhanced with the more realistic, dense visuals. This capability of manipulating the perceptual displays enables researcher to explore more fully the cognitive processing of field dependent and field independent learners. As Travers (1982) so aptly states, "The difference between the field-dependent and the field-independent person is particularly marked with respect to what is looked at and seen" (p. 75). Since field dependent and field independent learners process information either though global or detailed perspectives, the message form in terms of highlighting and sequencing of the density of the visual display could be manipulated to match their style of thinking. As a result, researchers can explore more fully the interaction of this cognitive style and display types. The following research questions are of interest:

- What effect does using graphic overlay have on learning for field dependent and independent learners?

- What effect does altering the sequencing of the display type have on learning for field dependent and independent learners?

Video windows and field dependence/independence. With the CBLS system, both video and text information can be displayed on the screen at the same time. Full motion video and audio can be played concurrently with the printed text from the computer. This capability offers great flexibility in the design of screen displays, but one area of relevance to this research agenda is its ability to display talking faces at the same time as text. While that may seem to be an inappropriate combination, given that another perceptual difference between field dependent and independent learners is their attention to people and faces, it follows that the addition of a more "human element" to the not-so-human computer environment may increase learning by field dependent learners, while the exclusion of these may enhance learning by field independent learners. The characteristics have led to the following research question:

- What effect will varying the inclusion and exclusion of a talking face to a text display have on learning by field dependent and field independent learners.

Alternate video and audio forms and modality strengths. Features of the systems which have been described in previous sections are also drawn upon in this section, but interrelated differently. The fact that we can store and manipulate large amounts of visual, auditory and textual data with relatively short computer processing time, enables the designers to store alternative modality presentation of the same material. The way this material is actually manipulated for instructional display challenges designers, and is therefore an important area for research. Research has shown that individuals do not necessarily select the modality which matches their learning strengths, however, it has been inconclusive as far as system driven matched modality is concerned. Also of importance in the selection of modality, is whether matched modality is really better for learning since attention may suffer from viewing "easy" material. The need for more exploration of these issues led to the following research questions:

- What effect does matching modality displays with modality strengths of learners have on learning?
- What effect does mismatching modality displays with modality strengths of learners have on learning?
- What effect does providing alternative modality presentation for those learners who are having difficulty have on learning?

Learner Control. A discussion of research with the CBLS would not be complete without recognizing the extreme importance of research on the interaction of learner control and all of the above variables. While this question is extremely important, it is the focus of many current studies of other researchers, and as such, will not be directly addressed in this list of questions. The results of those research studies will be carefully analyzed for applicability to these questions and where appropriate will be folded into the framework.

While we also realize that there are many more questions which could be addressed, we feel that we have selected some important "first issues."

Use of a Generic Research Disc

To conduct this research, we are proposing to follow the strategy Dwyer (1978) used to develop a series of guidelines for using realism in visual displays. Like Dwyer who developed nine general instructional treatments which varied level of realism from no visual to black and white line drawings to full color photographs of the heart, we will use a series of visual and auditory stimulus material which will be pressed onto a videodisc. The treatments for the various studies can, then, be altered through the sequencing, selecting of stimulus material (logic of the programming) and the addition or reorganization of text. By using this common set of visual materials, research results can be more legitimately synthesized.

In Dwyer's model, he selected a topic which would not be generally known to the population, as well as one which could be varied along the lines of levels of objectives. Following this lead, and also for very practical reasons, we have selected nutrition as the content area. Nutrition topics are of general interest, can be varied for level of objective, and for the most part, do not require too technical of prerequisite knowledge which would eliminate a major portion of the population. A large database of visual and auditory material currently exists. From this source, sequences appropriate to the research agenda will be selected for inclusion on the disc once specific outcomes have been specified. Their selection will be driven by the detailing of the research objectives listed above.

Maximum flexibility will also direct the selection of the final material to be pressed onto the generic research disc since the current agenda represents only a beginning of an evolving list of legitimate researchable questions possible with the computer based learning system.

Conclusion

The computer based learning system which currently can be described as combining interactive video and computer technologies offers new ways of displaying information to the learner. These new visual configurations enable researchers to examine how these perceptual displays can be matched effectively to the learner's information processing styles. Matching content and context, cognitive perceptual styles, and modality strengths have been highlighted out the myriad of potential question possible with this powerful medium and mark the beginning of continued exploration in this area.

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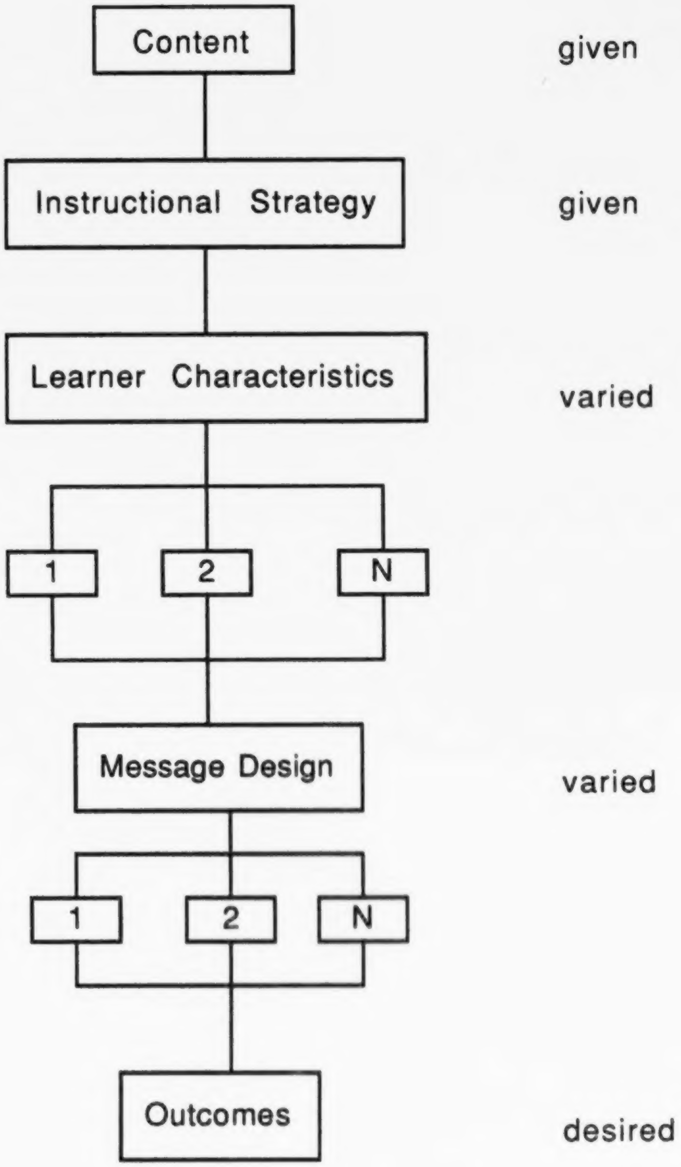
Content
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Figure 1

Title:

Application of Heuristic Methods in the Design of Intelligent CAI

Authors:

Dean L. Christensen
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Application of Heuristic Methods
in the Design of Intelligent CAI

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January 1988

Paper presented in the symposium, "Expert systems and the learning environment," Mariana Rasch (Chair), at the annual meeting of the Association for Educational Communication and Technology, New Orleans.

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Application of Heuristic Methods in the Design of Intelligent CAI

Intelligent computer-assisted instructional (ICAI) systems are characterized as holistic instructional inference-making systems that are iterative in nature such that with experience, they can continuously improve the learning of each individual learner (Tennyson & Park, 1987). This inference-making process is done by an intelligent expert tutor system which actively seeks to improve learning by (a) initially prescribing instruction that has a high probability of preventing learner error and/or misconceptions, (b) that continuously adapts the prescribed instruction according to moment-to-moment assessment and diagnosis, and (c) generatively improves its decision-making system. Figure 1 illustrates the various instructional variables that the MAIS expert tutor management system adapts to individual learner differences and needs during instruction (Tennyson & Christensen, 1988). These variables, termed computer-based enhancements, are managed by the expert tutor employing both formal and informal artificially intelligent (AI) heuristic programming methods (Dorner, 1983; Tikhomirov, 1983).

Insert Figure 1 about here

The MAIS

The intelligent learning system presented in this paper, the MAIS, is based on the findings of an extensive programmatic research effort investigating the direct connections among such learning environment factors as individual differences, cognitive learning theory, instructional technology, subject matter structure, and delivery systems (especially computer-assisted instruction). From the interaction of these factors, a MAIS-based ICAI program can be developed with reasonable success in reference to cost-effectiveness principles of improved learning within standard production costs. That is, unlike conventional ICAI demonstration (or prototype) programs that require costly dependence on powerful hardware and software systems (e.g., a LISP machine), a MAIS-based ICAI program can be developed within current microcomputer constraints of relatively limited memory.

Heuristic Programming

The purpose of this paper is to present the BASIC programming code for the heuristic employed in the MAIS. We have tried to make the following code as generic as possible so that anyone with at least a working knowledge of BASIC or some other language could easily design and program an ICAI. Remember that each of the variables of expert tutor is independent of the others, thus the selection of the individual variables is up to the designer. The only major dependent function needed to operate the MAIS expert tutor is the Bayesian conditional probability statistic. The Bayesian function sets the parameters of the mastery learning quality control of the MAIS. That is,

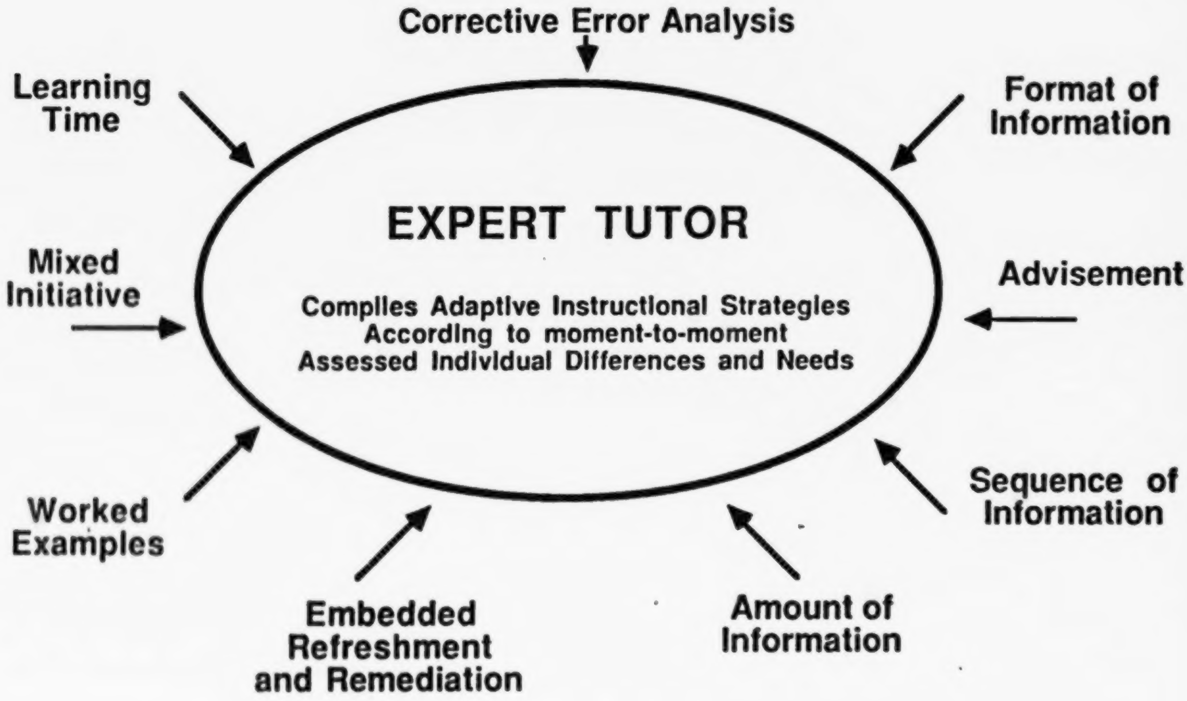
Corrective Error Analysis
Learning Time
Format of Information
EXPERT TUTOR
Compiles Adaptive Instructional Strategies According to moment-to-moment Assessed Individual Differences and Needs
Mixed Initiative
Advisement
Worked Examples
Sequence of Information
Embedded Refreshment and Remediation
Amount of Information

Figure 1. Illustration of Instructional variables monitored by the MAIS expert tutor.

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the Bayesian provides the information on the decision of whether to advance or retain the learner.

The statistical parameters in the Bayesian method allow the designer to determine the difficulty of the mastery learning decision. In our research we have established a standard format for the three parameters of the Bayesian statistic. Within this paper we will present only this standard format because it uses a heuristic that is very simple to program for use on a microcomputer. Advanced users may want to deal directly with the formula that calculates individual beta value tables. This information is in Tennyson, Christensen, and S. Park (1984).

The computer-based variables of the expert tutor are presented below as subroutines. Copies of an operating disk with sample lesson are available by writing directly to the authors.

Beta Value Computation

The Bayesian subroutine returns a two digit beta value for calculations that are needed in computing amount of information, advisement, and display time interval (Tennyson et al., 1984). The calculations in this standardized subroutine are an approximation of the incomplete beta function. The values from the incomplete beta function with a loss ratio of .3 (this figure is a statistical value in the Bayesian formula and ranges between values of .275 and .325, with the higher values resulting in increasingly conservative control over a false advance versus a false retain), a mastery criterion level of .75 (recall that this figure must include learning error, thus it may seem lower than usual levels for post test mastery learning objectives), and the number of interrogatory examples at 14 (this number could be increased, but should not really be decreased to maintain power of the statistic) is sent to a non-linear regression program that fits the best polynomial. The reason for the polynomial fit is to eliminate the need for calculating the beta value continuously throughout the program (this is certainly possible however on larger mini- and main-frame computers).

INPUT	The only input required is the number of examples correct and the number of examples presented.
OUTPUT	Two place beta value.

Variable List and explanation:

CORRECT	Number of examples that were correct.
PRESENT	Number of examples that were presented. (Note: The code PRESENT^2, means to the second power.)
BETA	Beta value.
C0, C1, C2	Variables used in polynomial

Code:

```
100 C0 = -.385747 + .0507146 * PRESENT - .00328486 * PRESENT^2 +
    .0000935574 * PRESENT^3
200 C1 + 1.37385 - .2958510 * PRESENT * .02450580 * PRESENT^2 -
    .0007305730 * PRESENT^3
300 C2 + -.273399 + .0767955 * PRESENT - .00725163 * PRESENT^2 +
    .00023077470 * PRESENT^3
400 BETA + C0 + C1 * CORRECT +C2 * CORRECT^2
500 BETA + INT [ABS(BETA * 100 + .5)] / 100
```

Mastery Check and Advisement

This subroutine uses the computed beta value to determine whether a given learner has mastered a given concept or rule (Tennyson & Buttrey, 1984). The mastery decision is used by the expert tutor to make a decision on when to terminate instruction. For learner control situations, the expert tutor advises the learner of his/her progress and recommends an appropriate decision, but allows the learner to decide when to terminate (Johansen & Tennyson, 1984). This subroutine reports to the learner, after each example, his/her current level of mastery regardless of learner control or program control. Note that multiple concepts and rules (coordinate) can also be used in this subroutine. In the following example code, the lesson has four concepts.

INPUT	Beta value Number of examples presented for each concept.
OUTPUT	Booleen statement--mastered or not mastered concept(s). BETA value PRINTED to advise learner of progress.

Variable List and explanation:

BETA(	Beta values from subroutine in array format
MASTERED(	Array to determine concept mastered (1) or not (0)
PRESENT(	Array for number of examples presented in each concept
CONCEPT	Number of concept
MAST	Accumulate mastery of all concepts
EX	Accumulate exhausted pool for concepts

Code:

```
XX10 REM Reset EX and MAST to 0
XX20 EX = 0:  MAST = 0
XX30 REM Mastery check
XX40 FOR CONCEPT = 1 TO 4
XX50 IF BETA(1) > 75 THEN MASTERED(I) = 1:  DONE = MAST = MAST + 1
XX60 IF PRESENT(CONCEPT) > 13 THEN EXHAUST = EX = EX + 1
XX70 NEXT CONCEPT
XX80 REM Determine if all concepts mastered or example pools exhausted
XX90 IF EX + MAST = 4 THEN (EXIT TO END OF PROGRAM)
X100 REM Print advisement
X110 FOR CONCEPT = 1 TO 4
X120 REM Format screen for your desired presentation
X130 PRINT BETA(CONCEPT)
```

X140 NEXT CONCEPT
X150 RETURN

Learning Time Interval

This subroutine monitors and updates the learning time of the interrogatory (practice) examples my increasing the amount of time for correct solutions (Tennyson & Park, 1984, 1985). This MAIS enhancement monitors learning time for two purposes: (a) to provide immediate instructional help if the learner has not yet developed sufficient procedural knowledge; and (b) to prevent the learner from being forced into making an incorrect response (Tennyson, Park, & Christensen, 1985). Monitoring the learning time is not a only a means to improve effectiveness of the instruction, but also to maintain efficiency of the learning environment. That is, time available for learning is a finite variable controlled by both external factors (e.g., school time periods, time of the day, excess to appropriate facilities, etc.) and internal factors (e.g., fatigue, attention, effort, etc.).

Because the parameters of this subroutine include statistical values concerning (a) difficulty of the concept, (b) difficulty of each example, and (c) update in learning progress, it is necessary to establish these values before using the learning time subroutine. In practice, we initially estimate these values and then collect actual times to precisely set the values. (A detailed discussion of these parameters is given in Tennyson, O. Park, & Christensen, 1984).

INPUT	Beta Value Example to presented next Example Difficulty Index (EDI) (mean time for experts to answer problem correctly) Concept Standard (statistical mean time of EDIs) Concept Difficulty Index (CDI) (statistical variance of EDIs) Lapsed time on example
OUTPUT	Learning time Concept Difficulty Index (value added to increase learning time)

Variable List and explanation:

LAPSE	Total elapsed time
LOCAL	Local current example's learning time
CDI(	Array for concept difficulty index
BETA	Beta value
EDI(	Array for concept difficulty index
RESPONSE	Last response 0 = Incorrect; 1 = Correct; 2 = Time elapsed
CONCEPT	Current concept being presented
STANDARD(	Array of concept standard
EXAMPLE(	The specific example to be presented next

Code:

```
XX10 REM Check learning time against elapsed time
XX20 IF LAPSE > LOCAL THEN RESPONSE = 2
XX30 REM Concept difficulty index subroutine
XX40 CDI(CONCEPT) = CDI(CONCEPT) + BETA * STANDARD(CONCEPT)
XX50 REM Learning time subroutine
XX60 LOCAL = EDI(EXAMPLE) + CDI(CONCEPT)
```

For example, if the total set of examples for a given concept has a mean value of 17 sec. (STANDARD), and a variance of 2.5 sec. (CDI), and a current beta value of .55, the calculation for the concept difficulty index would be the following:

CDI(Concept) = 2.5 + .55 * 17
CDI(Concept) = 11.85

For the next example (if current example correctly answered and an EDI value of 15 sec.), the learning time value would be increased as follows:

LOCAL = 15 + 11.85
LOCAL = 26.85

This heuristic allows for an iterative learning time increase with each succeeding correct response.

Formal of Examples and Sequence

This subroutine selects the format of the next example according to the response given to the current example, as follows: if correct or if time elapses, the next example will be in an interrogatory format; if incorrect, it will be presented as an expository example (Park & Tennyson, 1986). Also, this subroutine selects the sequence of the next example according to, first, the generalization rule (usually for the first four interrogatory examples) and, second, the discrimination rule (usually starting with the fifth example (Park & Tennyson, 1980). This subroutine also determines that no example is presented more than once and that no example is presented if the example pool is exhausted.

INPUT	Last response Concept presented and selected Number of examples for each concept presented
OUTPUT	Sequence of next concept and format of example

Variable List and explanation:

RESPONSE	Last response, 0 = Incorrect; 1 = Correct; 2 = Time elapsed
ANSWER	Last concept selected
EXAMPLE	Number of example selected
SEQUENCE	0 = Generalization; 1 = Discrimination

MASTERED(Array to determine concept mastered (1) or not (0)
PRESENT(Array for number of examples presented in each concept
CONCEPT Number of concept

```
XX10 REM Select example number from pool
XX20 EXAMPLE = INT(RND(1) * 14 + 1
XX30 REM First four examples presented in each concept are generalization
XX40 IF SEQUENCE = 1 AND PRESENT(CONCEPT) < 5 THEN SEQUENCE = 0
XX50 IF SEQUENCE = 1 AND PRESENT(CONCEPT) > 4 THEN SEQUENCE = 1
XX60 REM When response is incorrect or time elapsed and generalization is in
     effect then concept to be selected remains the same
XX70 IF RESPONSE = 0 OR (RESPONSE = 2 AND SEQUENCE = 0) THEN GOTO X120
XX80 REM If response is incorrect and discrimination then next concept to be
     selected is the learner's incorrect response
XX90 IF RESPONSE = 0 THEN CONCEPT = ANSWER:  GOTO X120
X100 CONCEPT = INT(RND(1) * 4 + 1)
X110 REM Determine example pool exhausted / If exhausted then response must be
     changed to correct so random select of concept occurs
X120 IF PRESENT(CONCEPT) > 13 THEN RESPONSE = 1:  GOTO XX10
X130 REM If response is correct and concept not mastered then start over
X140 IF RESPONSE = 1 AND MASTERED(CONCEPT) = 0 THEN GOTO XX10
X150 REM If example was used before start over
X160 IF SELECTED(CONCEPT,EXAMPLE) = 1 THEN GOTO XX10
X170 SELECTED(CONCEPT,EXAMPLE) = 1
X180 RETURN
```

The variables of corrective error analysis and embedded refreshment and remediation are task-specific enhancements that are designed at the point of individual lesson development. The important concept for the former variable is to consider the type of analysis as a function of the instructional strategy to be employed. For the latter variable, the design decision comes from the structure of the content to be learned. Both of these variables need attention so as to provide adequate instructional help, but not to the point of reducing efficiency of the learner. For example, too much interference from adjunct instruction can distract the learner and consequently use up valuable learning time.

Summary

Our purpose in this paper was to present the program code of the heuristics employed in the MAIS. The MAIS program is supported by both learning theory and instructional theory. Also, the instructional variables and conditions of the MAIS are supported by empirical verification; tested in a well-defined program of research, and evaluated by disciplined peer review. The value of the theory-based instructional design system supported by direct research findings is that it can be generalized to specific learning needs and conditions. And, for implementation purposes, the MAIS is readily transferable to most currently available hardware and software. And, as computer technology itself improves, it will be possible to both enhance the present variables and conditions yet to be discovered. Some of these new variable will come from research in such diverse areas as individual differences, human-machine interface design, neuropsychology, psychometrics, computer software, perception, and the continuing significant research and theory development in the field of instructional technology, curricular management as well as hardware and software developments.

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Title:

Professional Ethics: An Analysis of Some Arguments for Development of Virtuous Behavior

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The Association for Educational Communications and Technology

Annual Convention

New Orleans, Louisiana

January 17, 1988

Professional Ethics: An Analysis of Some Arguments for Development of Virtuous Behavior

by

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After a long period of relative inactivity, we have seen a resurgence in interest in the topic of professional ethics in ours and related fields. Recent activation of our Professional Ethics Committee, convention sessions like the one today, articles in professional and scholarly journals, all signal a level of interest that has not been present for several years. It is not an original thought that the wide-spread reporting of misconduct on the part of business leaders, financial traders and professionals of all sorts, is a significant cause of this resurgence of interest. The general hypothesis seems to be these public failures are a symptom of a general shift in the moral values that guide behavior between and among professionals and clients in our society.

A major assumption of this paper is that much of the public discussion is irrelevant to our concerns as professionals. The "micro" moral decision making processes that constitute the day to day fabric of ethical behavior hold much more philosophic and psychological interest to practicing professionals. The personal failures that are publicly reported are qualitatively different and although that may be the result of an aggregate of ethical decisions across time, they are not very interesting in either a philosophical or psychological sense. They provide little useful content for a philosophic or psychological analysis of the conditions that promote virtuous behavior.

The major premise of this paper is that virtuous behavior, (Frankena 1976) trait-like behavior that meets or exceeds the commonly held values of the profession, can be fostered by associations' of professionals. This virtuous behavior must be well understood and modeled if this influence is to benefit the profession.

Before more specific issues can be discussed, a number of definitions must be considered. First principles or moral rules (Frankena 1976) are often suggested or implied in professional codes of ethics. In the AECT Code of Ethics, (Human Resources Directory, Page 6) several commonly held moral roles may be tacitly seen in the twenty two secondary principles stated in the code. The rule "do no harm", may be inferred in Section I, item 4, "Shall conduct business so as to protect the privacy and maintain the personal integrity of the individual." The rule "treat all equally" may be inferred in Section II, Item 5, "Shall engage in fair and equitable practices with those rendering service to the profession." These general rules or first principles are not easily derived in a philosophic sense. Some philosophers argue that these principles are a part of our basic nature, (Ross. W.D.) some others argue that they can be empirically derived. (Rashdall, H.) In any event, these first principles often form the core of beliefs of religious groups, societies, or professional groups. It is curious that these principals are rarely made explicit. They seem to be assumed as a part of the implicit norms of the group of individuals who hold these views, especially in professional societies.

These moral rules are most often used in the manner of Socrates when in engaged in moral reasoning. (Frankena 1973) If, for example, an educational technologist has completed an analysis of different computers to deliver instruction for his/her institution and two or more vendors could successfully compete to fulfill the technical requirements of the analysis, the first principle,"treat all equally" and "do no harm" could be shown to be applicable to the situation in which two or more vendors were competing for the right to sell the computers. Further, if one of the vendors offered a personal gratuity to the educational technologist, the technologist could reason: "If I accept the gratuity, I will not be treating the vendors equally, and, "If I accept the gratuity, I will be harming the reputation of my institution and my profession." Both of these logical moves bring the principle together with the facts relevant to the decision to be made. Then the educational technologist would come to the conclusion that he/she could not accept the gratuity even if the bid for the computers was the lowest competitive bid. This rather abbreviated and straightforward example has the advantage of illustrating the three part process of moral reasoning: 1) statement of first principles, 2) combining first principles with relevant facts, and 3) drawing a conclusion in a rational and dispassionate manner with some understanding of the consequences of the alternatives. In more complex situations, the application of principles may not lead to the same conclusion. Then it is usually necessary to decide which principle takes precedence. The dialogue in the process of discussing a specific moral decision could well involve the challenge of the principles, the decisions of which rule is more basic or fundamental or the logic by which conclusions were derived from facts and principles.

I have used the term moral several times in this discussion. From the philosophic perspective, ethics is a branch of moral philosophy. (Brody) (Vallance) Moral reasoning defined above is an analytic philosophic process having to do with moral decisions of right and wrong, duty or obligation wherein the alternatives affect individuals or groups of individuals. In our profession, we have a deep and abiding interest in at least two types of moral knowledge. 1) We are often interested in a psychological or anthropological sense in the values or norms of our client systems or our own culture as in Paul Welliver's paper delivered today. We pursue scientific knowledge about moral meaning that affects the conduct of our professional duties. Some times we pursue knowledge to influence the client system in educational or training interventions and at other times, to model in a scientific sense, moral meaning and behavior in our profession. 2) As judging by our collective scholarly behavior, we have an interest but perhaps less abiding in the philosophic questions of what is good or what duties or obligations coincide with our professional status. In section I of our ethical code, (Human Resources Directory, P. 6) our colleagues who wrote the document take it as inherently good that we "promote correct and sound professional practices in the use of technology in education" or that it would be wrong in Section II to "use institutional or associational privileges for private gain." These are philosophic normative assertions of right and wrong. We have, presumably in a scholarly manner, engaged in philosophic reasoning that lead to these assertions. This important form of inquiry is nearly non-existent in our profession.

There is a third kind of philosophic moral inquiry that deals with meta issues that are more often than not left to philosophers. They include such issues as: What is the meaning of good or bad in an expression of moral reasoning?" Or perhaps more relevant to our discussion today, how do we distinguish between moral and non-moral decisions? At any rate, the philosophic inquiry of this type is usually outside the realm of our professional discourse. It is however, quite relevant to our gaining sufficient prowess in ethical decision making over time.

The common use of the terms ethical or moral are usually associated with good and the opposites unethical or immoral are of course associated with bad or wrong motives and subsequent behavior. (Frankena 1973) Philosophers use quite different distinctions that are important to our discussion. Moral is a term that is defined as coordinate with history, science or other disciplines. The opposing terms would be non-moral or non-ethical. So in an expanded process of moral reasoning, the first step would be to distinguish between decisions that are moral or pertain to morality or ethics and those that are technical or non-moral. For example, I once invested a great deal of intellectual energy dialoging with myself about the "ethical" decision of portraying a faculty member as excellent or adequate in a problematic tenure case. After considerable time and energy was invested, I decided that the decision wasn't ethical at all it was non-moral ("non-ethical"). I was being asked to excercise a technical judgment based on the science of my profession. The tenure rules were well understood and accepted by all parties. All parties had acted in a manner consistent with moral rules I knew. The decision could have been ethical or moral if issues of duty, obligation, rightness or wrongness of the process or individual behavior associated with my decision to characterize the faculty member as adequate or excellent had been involved. In this case, I reasoned that there was sufficient evidence to come to a technical judgment based on the evidence at hand. My concern for the faculty member was an emotional concern not primarily related to first principles of right or wrong, duty or obligation.

Virtue is a term not often used in professional prose. Virtue in this context means the disposition to behave in a manner consistent with moral values or moral principles. As noted above, the most important premise of this paper is that we have a professional obligation to create conditions which illicit and promote virtuous conduct. To focus exclusively on moral reasoning or conformity to rules is inconsistent with our professional knowledge. As an applied psychological profession, we certainly believe that complex rule like behavior is not tenable without addressing the motivation or higher order meaning that promotes that behavior. Certainly the publishing of a code of ethics with no provision for explanation, application or interpretation in a training context would be uniformly considered inadequate behavior on the part of qualified instructional designers. One wonders why we find it acceptable to provide this limited training support for practicing professionals in our profession.

What would constitute adequate conditions for fostering virtuous professional behavior in our associations? We certainly should more actively pursue the first two kinds of moral knowledge discussed above. The study of our professional conduct is certainly a proper and worthwhile scholarly goal. We should invest considerable energy in describing moral meaning and behavior in our profession. We would certainly be well advised to model and predict this behavior as well. Our scholarly journals should solicit such inquiry if it is not readily forthcoming. Also, we should use this knowledge to change our training programs and to modify the conduct of our professionals in our society.

In addition, we should encourage our own scholars or solicit philosophers to engage in philosophic inquiry that allowed us to be more clear about the meaning of our moral values. We should define the first order and secondary principles that are relevant to our profession. We should attempt to prioritize our values and examine those priorities in difficult cases. (Vallance)

We should explore moral reasoning in our literature and in our training programs. The process of moral reasoning is largely untaught in our professional programs and it is unexamined in our professional literature. The process requires sophisticated knowledge and reasoning processes. We certainly treat far less important professional goals more seriously than we regard this vital skill.

We should re-examine our professional code of ethics and clarify the scholarly assumptions and analysis that went into the design of the code. Our code is a fairly traditional statement of second order or applied principles of duty and obligation. At a minimum, our more primary principles should be made explicit and examples or case vignettes should be published so that the code of ethics can be applied with more precision and sophistication. It seems that the authors of our code and comparable codes feel that the codes are self evident in their application. Certainly our status as professional educators would suggest fallacy of that assumption.

The dispositions or traits of virtuous professionals should be more carefully described, analyzed and promulgated. If we are serious about our concern for moral decision making in our profession, the best models of this disposition must be made explicit and held up as worthy of emulation. In our pluralistic society, we seem to believe that matters of virtue and moral behavior are not proper concerns for professional dialogue outside the churches, synagogues or other religious institutions of worship. It has often been my experience that words such as virtue or moral values evoke ridicule or uncomfortable silence in professional dialogue. It seems to me that the very fact of our pluralism argues for a scholarly professional inquiry and development in the ethical issues of our profession. Our duty is to be clear with one another about moral decision making and particularly the conditions that promote virtuous behavior. We seek not to replace our religious institutions we must exceptionally be clear about the moral decision making in those arenas where many ideologies intersect in our society. Otherwise we create an environment of moral uncertainty or professional caveat emptor.

In summary, I should say that there are several limitations to my arguments especially my philosophic arguments. In some cases, time and space did not permit more complete arguments. For example, I have taken a position which philosophers label deontological. (Brody) That is, I speak of moral decision making as a process derived from moral rules or first principles. This position is held in contrast to a teleological position which would argue that first principles cannot be derived and that non-moral good or consequences of moral decisions would be the basis for making moral decisions. Decisions would be made to achieve the greatest good. Interesting and useful arguments about professional ethics could be made from a teleological position. However, the conclusion of this paper would be the same. We have a duty to create greater understanding of and the conditions which promote virtuous behavior. Also, my philosophic arguments are the arguments of a student rather than the master of the discipline. This is the dilemma of many professionals interested in professional ethics. Gaining competence is difficult because our training was in other disciplines.

Finally, the last stage of my argument was more psychological than philosophical. In essence, I argued that our professional knowledge about teaching complex understandings and rule behavior would lead inevitably to a change in our current professional practices in areas of training professionals, publishing scholarly works and association actions. I believe the argument could be made just as well on philosophic grounds. In brief, if we are committed to concepts of duty, obligation or right actions as basic to our professional status, that commitment should lead to a better philosophic definition and understanding of what we mean by those terms and that understanding in turn would lead to the specific duty of creating appropriate conditions to foster virtuous behavior.

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